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VOLUME II

RECOMMENDED PROGRAM

MANDATORY VEHICLE EMISSION INSPECTION AND MAINTENANCE
PART A - FEASIBILITY STUDY
FINAL REPORT

Prepared Under Contract

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with
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Air Resources Board

Approved by

R. L. Gibney, Vice President
Environmental Systems

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NORTHROP CORPORATION
Electro-Mechanical Division
500 East Orangethorpe Avenue
Anaheim, California 92801

in association with

OLSON LABORATORIES, INC.

FOREWORD

The Second Annual Report of the Air Resources Board, titled "Air Pollution Control in California," published in January 1970, documents the activities of the Board during 1969. In addition to a review of its many accomplishments, it was stressed that many problems remained to be solved. One of these was to determine the effects of various maintenance procedures on exhaust emissions and to develop a practical vehicle inspection program. In accordance with a legislative directive (AB76), the Air Resources Board issued a Request for Proposal on July 3, 1970, to conduct a Vehicle Emission Inspection and Maintenance Study that would determine the feasibility of such a program. Northrop Corporation, Electro-Mechanical Division, was selected to perform this study; Standard Agreement number ARB-1522 was consummated on November 30, 1970. Part A of the study addressed the overall feasibility and public acceptability of a program of mandatory vehicle emission inspection and maintenance. Part B of the total study which will be completed during November 1971 will obtain data on the reductions of automotive emissions that can be achieved through vehicle inspection and maintenance.

Part A of the study has been completed, documented, and is presented herewith in accordance with the requirements set forth by the Standard Agreement. This final report is presented in four volumes. Volume I is the Summary which provides a synopsis of the analytical methodology employed to determine and evaluate the feasibility of a statewide inspection program. The findings and results of the analyses are summarized, and recommendations for further effort are provided. Volume II is the Recommended Vehicle Emission Inspection and Maintenance Program. Volume III is the Technical and Economic Feasibility Analyses. It describes the conduct of the study; provides the findings, results, and conclusions of the analyses; and recommends areas for further investigation. Volume IV is the appendixes which contain data references, relevant correspondence, instrumentation survey data sheets, and other substantiating documentation.

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SECTION 1
INTRODUCTION

The Key-Mode test regime is recommended for statewide implementation. This recommendation is based on the technical and economic feasibility analysis results. A complete description of the study approach, the various analyses, and the results obtained are documented in Volume III. Based on the analytical results and conclusions, the recommended Key-Mode implementation is derived that incorporates the findings of the feasibility analyses and the sentiments of the general public.

1.1 SYNOPSIS OF STUDY METHODOLOGY

A general requirements analysis was conducted to identify and describe those technical and regulatory factors that would affect a vehicle emission inspection program. Both functional and operational analyses were then performed to describe and define various configurations of alternative test regimes. An extensive instrumentation survey of available and near-term equipment and systems was conducted to determine degree of adequacy and availability to satisfy inspection facility requirements.

The acquisition of both emission reduction data and related vehicle owner's cost data was facilitated by the early definition and refinement of a vehicle testing program developed in conjunction with the Air Resources Board staff at Los Angeles. Two independent but related computerized models utilized the data to expedite and simplify the calculations and projections of program effectiveness (measured in emission reduction) and total costs as a function of a calendar year, test regime, and emission pollutant.

A comprehensive questionnaire was developed jointly by the ARB, Northrop, and Opinion Research of California, that addressed all facets of a mandatory, periodic, vehicle emission program. Two groups of people were interviewed by Opinion Research - the general vehicle-owner populace and special-interest groups related to and active in the automotive industry - to determine their sentiments regarding the factors related to the program.

Analysis results were combined to perform an overall cost-effectiveness appraisal of the alternative methods of achieving emission reduction. Quantitative cost-effectiveness indices were determined as a function of calendar year, test regime, program management, and inspection facility ownership and operation. Additionally, a qualitative analysis of uncertainty factors such as growth capability and future technological effects was conducted.

The extent to which the State and the private sector participated in an inspection program was determined by considering the results of the cost-effectiveness analysis and the public opinion survey.

1.2 CONCLUSIONS LEADING TO THE RECOMMENDED IMPLEMENTATION

The Key-Mode test regime is recommended as a result of the technical, economic, and public acceptability analyses conclusions presented in Section 10 of Volume III. The conclusions that led to the recommended Key-Mode implementation are listed below:

- Most effective in achieving emission reduction during the initial 5 years
- Most cost-effective of the alternatives considered when evaluated during the initial 5 years
- Essentially equal to Idle test after the initial 5 years
- Achieved the best figure of merit in terms of vehicle owner's cost per emission reduction
- Exhibited the best fuel savings potential per serviced vehicle
- Experienced the second lowest average vehicle owner's cost per serviced vehicle (Certificate of Compliance was lowest)
- Resulted in the second lowest annual inspection fee of $1.05 (Idle test was lowest with $0.96)
- Incurred the second lowest initial investment costs (Idle test was lowest)
- Shows equal flexibility with Diagnostic test in adapting to future emission measurement requirements.

1.3 RECOMMENDED IMPLEMENTATION

In the ensuing sections of this volume, the physical, functional, and operational descriptions of the Key-Mode test regime are provided. Specific benefits and features of a Key-Mode inspection program are outlined.

Detailed physical descriptions of typical inspection facility configurations are presented along with the identification of required instrumentation and technical personnel. The various test procedures, operational tasks, and administrative functions are described in an operational narrative that portrays the typical activities that occur at the inspection facility.

Approximate physical placement of the recommended Key-Mode facilities are identified. Initial estimates of lane requirements are also noted for each location that would accommodate the calculated workload.

A recommended program management structure is defined that will provide the necessary management, administration, and surveillance on a statewide basis. Areas requiring further study based on the results of the feasibility analyses are identified. To assist the responsible State agency, the volume contains an overall recommended implementation plan that addresses immediate and near-term objectives of achieving reductions in vehicle exhaust emissions.

SECTION 2
KEY-MODE FEATURES AND BENEFITS

A State managed, owned, and operated system of Key-Mode inspection facilities has been found to be the most cost-effective means of performing vehicle emission inspection to achieve reduced levels of emitted hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x). The technical and economic feasibility analyses documented in Volume III of this final report demonstrates that this inspection test regime was consistently superior to all others analyzed. The Idle test compares favorably with the Key-Mode test as the vehicle population distribution attains a higher percentage of controlled vehicles. This favorable condition occurs initially ~~about 1979.~~ A qualitative analysis of factors dependent on future circumstances indicated that the Key-Mode test provides the necessary adaptability to accommodate the long-term inspection requirements posed by the Clean Air Amendments of 1970. This growth capability, which is primarily a function of the dynamic test capability provided by Key-Mode, is not characteristic of the Idle test regime.

2.1 COST EFFECTIVENESS

The Key-Mode test has inherent advantages over other tests in that it is a highly developed and refined methodology that closely relates inspection procedures with service and repair activities. It is based on the results of many pilot programs, test samples, and data analyses. The three basic modes of vehicle operation and the corresponding emission levels have been correlated to identify the most probable causes of excess emissions in terms of engine and emission control system components. Both the inspection procedures and service and repair guidelines are well documented, thus resulting in effective performance of required servicing without excessive diagnosis and associated costs.

The feasibility analyses have indicated that this form of inherent diagnostic capability is a primary determinant of cost-effectiveness in realizing maintenance-related emission reductions. The more comprehensive and complete the information the test provides to the automotive repairman about the causes of excessive emission, the less time is required to consummate an effective repair. Cost is reduced as a consequence. This was a significant factor in the superior cost-effectiveness of the Key-Mode test.

These service and repair guidelines will be an essential link between the State-operated inspection facilities and the privately operated repair facilities. Additionally, they should provide the vehicle owner with assurance that only those repairs and services required to reduce emissions are being performed on his vehicle. The effectiveness analysis showed that Key-Mode test experienced the greatest emission reduction during the initial 5 years of operation over any other alternative considered.

The cost analysis of the Key-Mode test regime on a total program basis indicated that the State passenger vehicle population could be inspected at an annual inspection fee of $1.05. The least costly test regime was determined to be Idle test with an annual fee of $0.96 per vehicle. Both of these fees are based on the assumption that the State would manage the program and also own and operate the inspection facilities. The corresponding vehicle owner's service and repair costs would be $24.86 per serviced vehicle for Key-Mode. As a matter of interest, Idle test serviced vehicles would incur a repair cost of $27.19 on the average. Based on a vehicle owner's cost-effectiveness evaluation, the Key-Mode test regime realized the greatest emission reduction per vehicle owner's total cost (inspection fee plus repair cost). Additionally, it was demonstrated that Key-Mode serviced vehicles exhibited the greatest potential for fuel savings based on emission reduction achieved.

2.2 SIGNIFICANT FEATURES

Table 2-1 summarizes the major characteristics of the recommended statewide vehicle emission inspection program.

Table 2-1. CHARACTERISTICS OF KEY-MODE TEST REGIME IMPLEMENTATION

Characteristics	Significant Feature
Program Management	Appropriate agency of the State of California
Inspection Facility Ownership	Appropriate agency of the State of California
Inspection Facility Operation	Appropriate agency of the State of California
Inspection Fee	Estimated to be $1.05 per vehicle annually
Vehicle Inspection Time	Average test duration of 4.8 minutes
Driving Distance to Facility	Typical owner's distance of 10 miles
Service and Repair Activities	Private sector
Service and Repair Costs	Estimated to be $24.86 per serviced vehicle
Reinspect serviced vehicles	Recommended
Reservice failed vehicles	Not recommended during initial year of operation
Fuel Savings Potential	Estimated to be $8.70 per serviced vehicle
Serviced Vehicle Performance	68.5 percent of owners would conclude that performance improved, 20 percent would detect no change or degradation
Program Implementation	
Immediate (1971-1972)	Upgraded Certificate of Compliance testing
Near-term (1972-)	Key-Mode test selective implementation by air basins

SECTION 3
INSPECTION FACILITY LAYOUT

Uniform inspection stations of the type shown in Figure 3-1 would be characteristic of a State-operated vehicle emission inspection program. A typical four-lane inspection station would require approximately one acre of land, which would include areas for the inspection building; vehicle ingress, queueing, and egress; employee parking; and room for at least one-lane modular growth. The building area for a single lane station would have 2,040 square feet and an additional 1,020 square feet would be required for each additional lane.

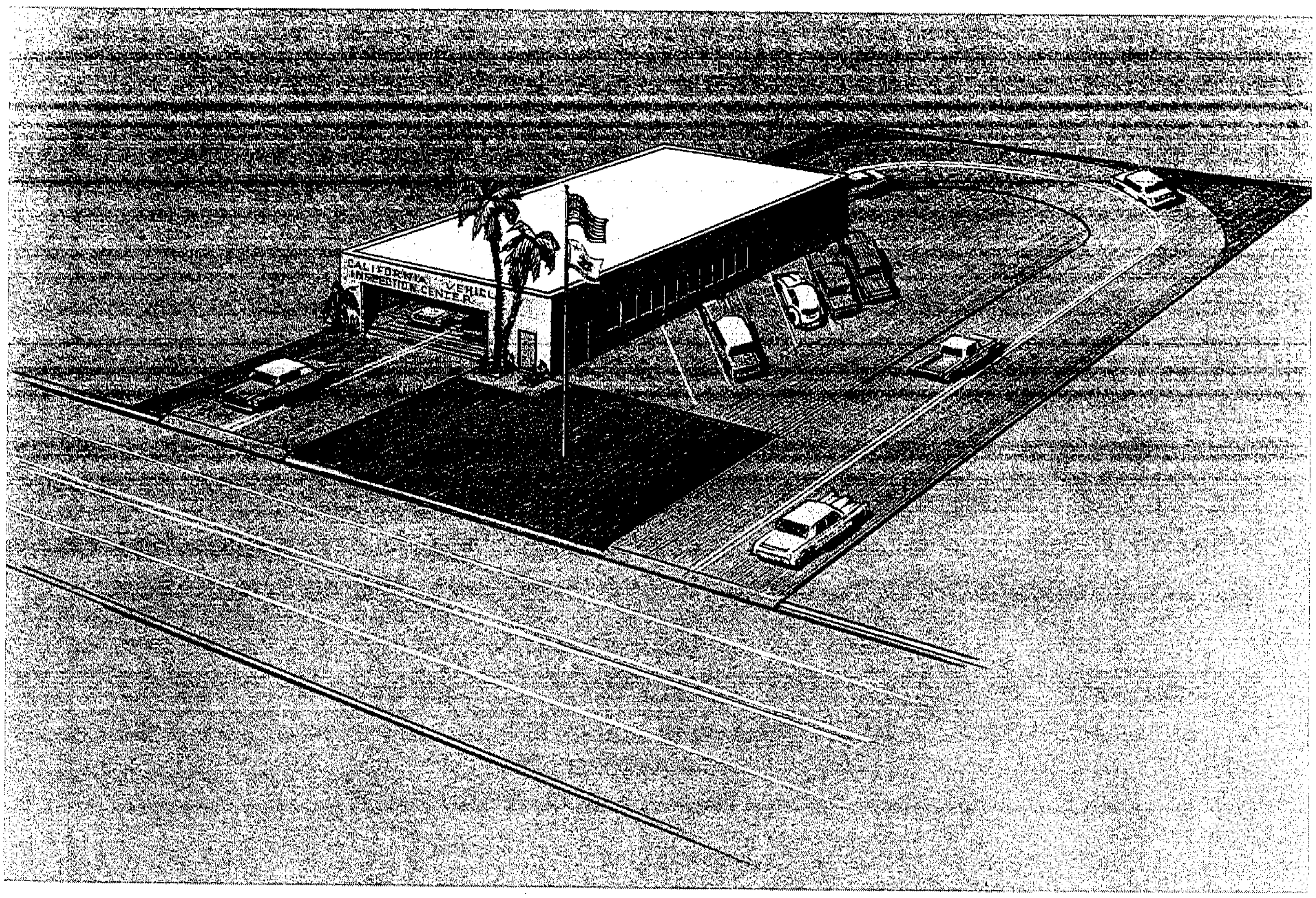


Figure 3-1. ARTIST'S CONCEPTION OF STATE-OPERATED KEY-MODE INSPECTION STATION

Figure 3-2 shows the floor plan for a four-lane Key-Mode inspection station, and Figure 3-3 shows an artist's conception of a two-lane Key-Mode inspection facility. The modular method of construction employed features baseline configurations of

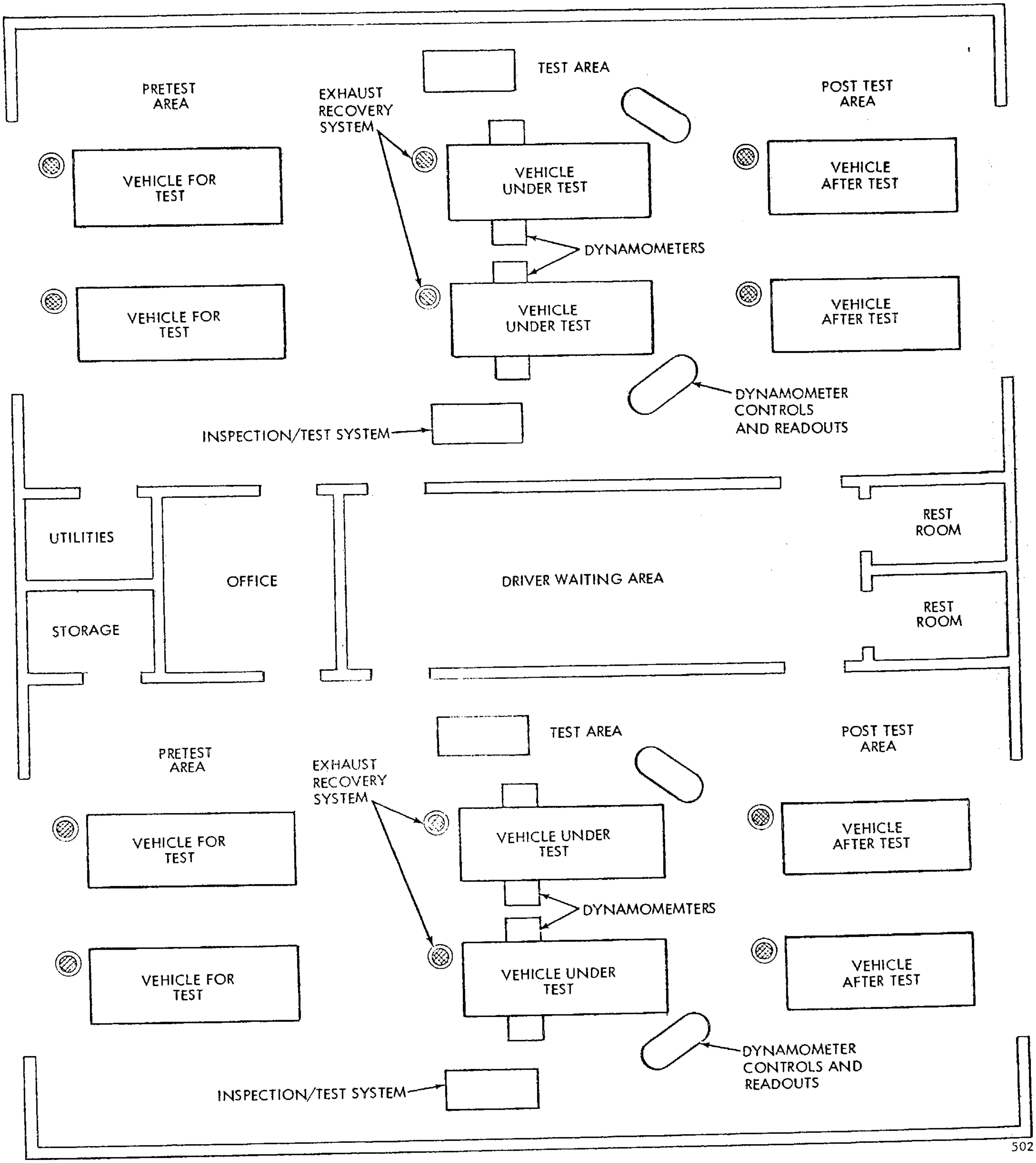


Figure 3-2. FOUR-LANE KEY-MODE INSPECTION STATION FLOOR PLAN

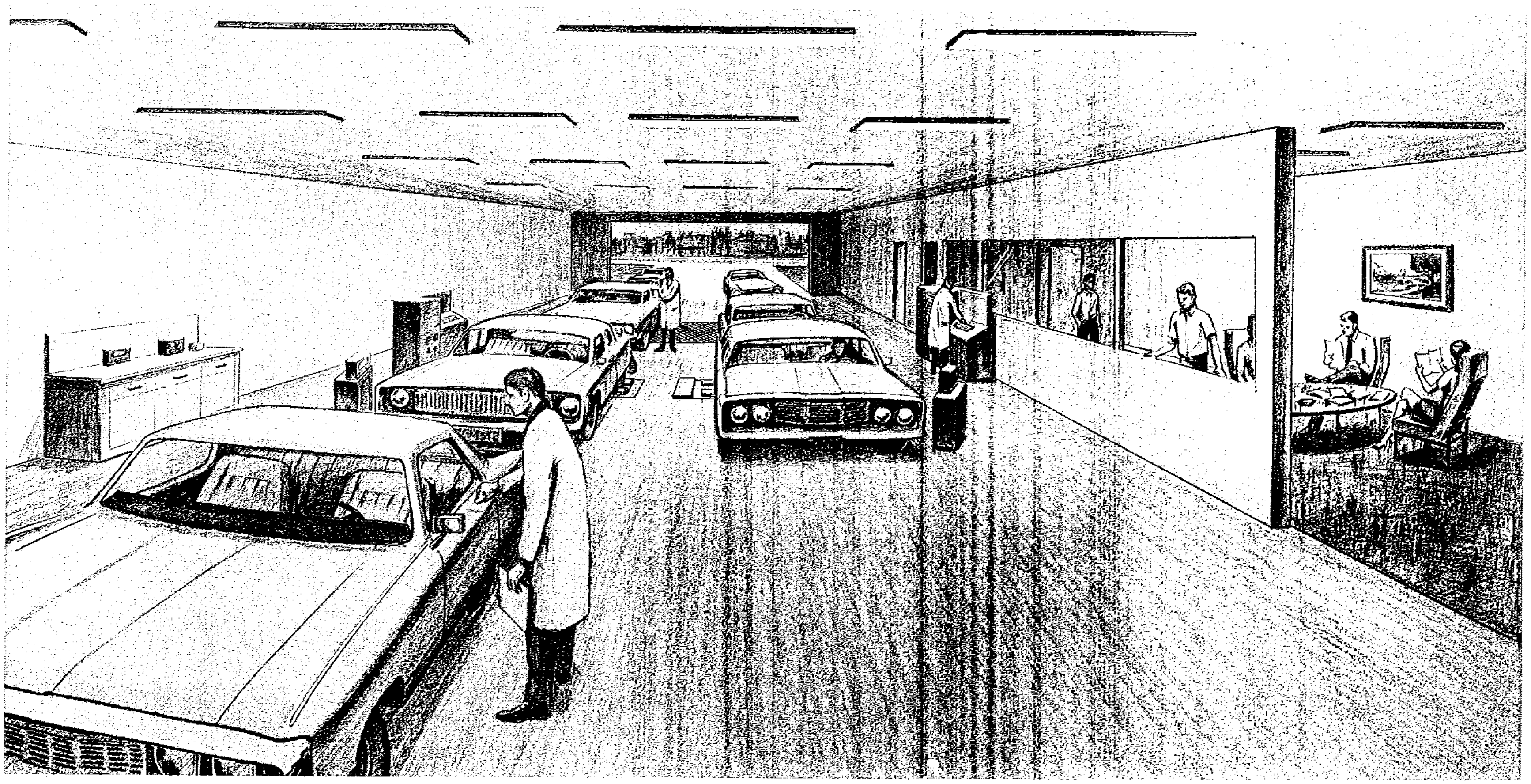


Figure 3-3. ARTIST'S CONCEPTION OF INTERIOR VIEW OF KEY-MODE INSPECTION FACILITY

one- and two-lane stations which may be combined into larger stations by placing them side by side. The single lane station is configured around a single inspection lane consisting of the equipment described in the following section, a small public waiting room, office space sufficient for one desk and table, and a restroom. The two-lane station is configured simply by adding a modular lane to the single lane configuration. For growth to a three-lane station, a duplicate single lane station, opposite in floor plan to the first, is added with the office and restroom areas back to back. This form of modular growth may evolve as required by the vehicle population served by the station.

The interior configuration accommodates vehicles during the pretest inspection, test, and post-test functions. Vehicle emission measuring instruments are placed in rollered cabinets so that they can be positioned conveniently by the inspectors and technicians. The compressed calibration gases and any explosive or inflammable materials are placed in an enclosure outside the main building.

The station is equipped with compressed air, 110-volt a-c electrical power, and exhaust removal systems placed in the floor of the inspection lane. An inspection pit would not be required but would be optional for an inspection program that includes a safety check. For the vehicle emission inspection purposes, the oxygen analyzer incorporated in the instrument package will permit accurate measurement of any air dilution (leakage or control system). A procedural check of the vehicle's exhaust system integrity will be performed by the test technician. This is done by blocking the exhaust pipe during idle at the pretest check to see if leaks are apparent. A rollered mirror would also be available to discover gross exhaust system deterioration.

The exhaust removal system is integral with the floor of the station and conveys the exhaust gases to the side walls and hence to the roof of the structure where they are discharged. The exhaust gases are recovered during each phase of the inspection.

The basic building construction method consists of wood frame and stucco. Structures up to four lanes wide can be built without interior columns since the interior walls on the large stations will support the middle of the roof span.

SECTION 4
INSTRUMENTATION AND EQUIPMENT INSTALLATIONS

The minimum equipment required to implement the Key-Mode test in a single-lane setup consists of a chassis dynamometer, an instrument console, and a data processing set. Components of the instrument console and data processing set are listed in Table 4-1.

Table 4-1. COMPONENTS OF THE KEY-MODE INSTRUMENT CONSOLE AND DATA PROCESSING SET

Item	Nomenclature	Specifications	
		Range	Accuracy
1	CO Analyzer	1-10%	1% Full Scale
2	HC Analyzer	0-1000 ppm	1% Full Scale
3	NO Analyzer	0-2500 ppm	1% Full Scale
4	O_2 Analyzer	0-10%	2% Full Scale
5	Sampling System	Provide Clean Dry Sample Cooled to 95°F	
6	Data Processor	See Text	
7	Card Punch Machine	Standard	
8	Frame and Assembly	As Required	

The instrumentation console and data processing set consists of a combination of modified off-the-shelf instruments and sampling equipment combined with a small special-purpose data processor and customized input panels mounted on an instrumentation rack. The processor and input panels are not presently available in the specific form required, but their design is simple and straightforward, requiring no development. All the necessary components are commercially available. Currently available instruments must be equipped with linearizing circuits and digital outputs. These added features have not been generally supplied with exhaust gas analyzers but are commercially available on other instruments.

The card punch machine used in this system may be most economically supplied by leasing. If this is finally determined to be the case, the design will allow for handling this component as a separate unit. The schematic diagram of a typical system is shown in Figure 4-1. In addition to the instrumentation, a chassis dynamometer must

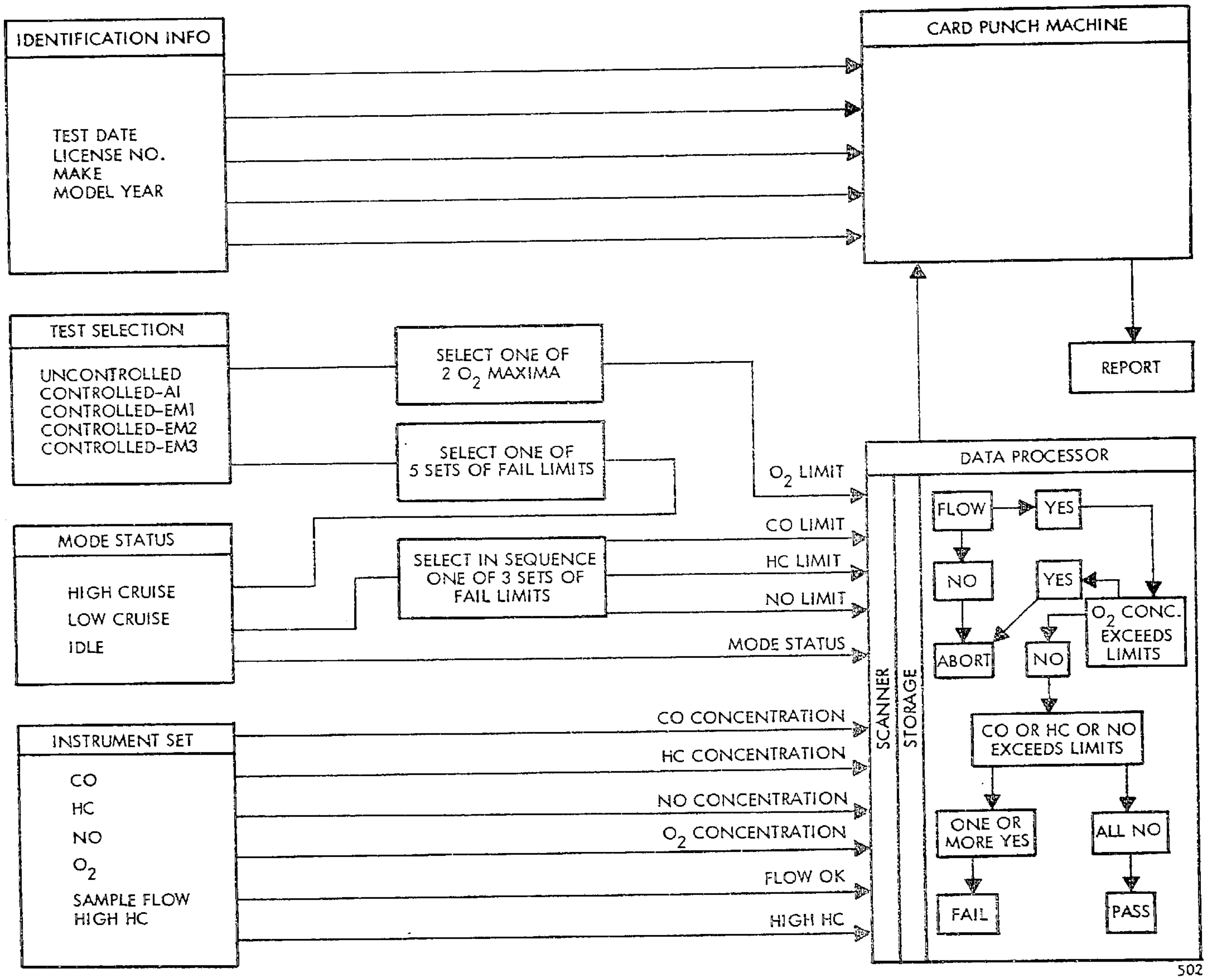


Figure 4-1. SEMIAUTOMATIC VEHICLE EXHAUST GAS INSTRUMENTATION SYSTEM

be installed on the inspection lane. The Clayton Model C-71 or equivalent is adequate for this requirement.

The equipment required for a modified Certificate of Compliance test which incorporates elements of the Idle test (see Implementation Plan, Section 10) will consist of a simplified CO-HC analyzer with the possible later addition of an NO_x channel. This modified test is recommended for incorporation in upgraded Class A inspection stations as an interim measure to allow early implementation of the total vehicle inspection and maintenance program. Equipment having the required capabilities for this function is presently commercially available from several suppliers. It is a desirable, if not essential, requirement for proper maintenance of modern exhaust emission systems.

For measuring emission levels of pre-1971 control systems, NO_x instrumentation may not be required provided that minimum and maximum CO limits are established to optimize the HC and NO emission levels. Hydrocarbon instruments are required to detect lean misfire and other ignition problems.

SECTION 5
KEY-MODE TEST DESCRIPTION

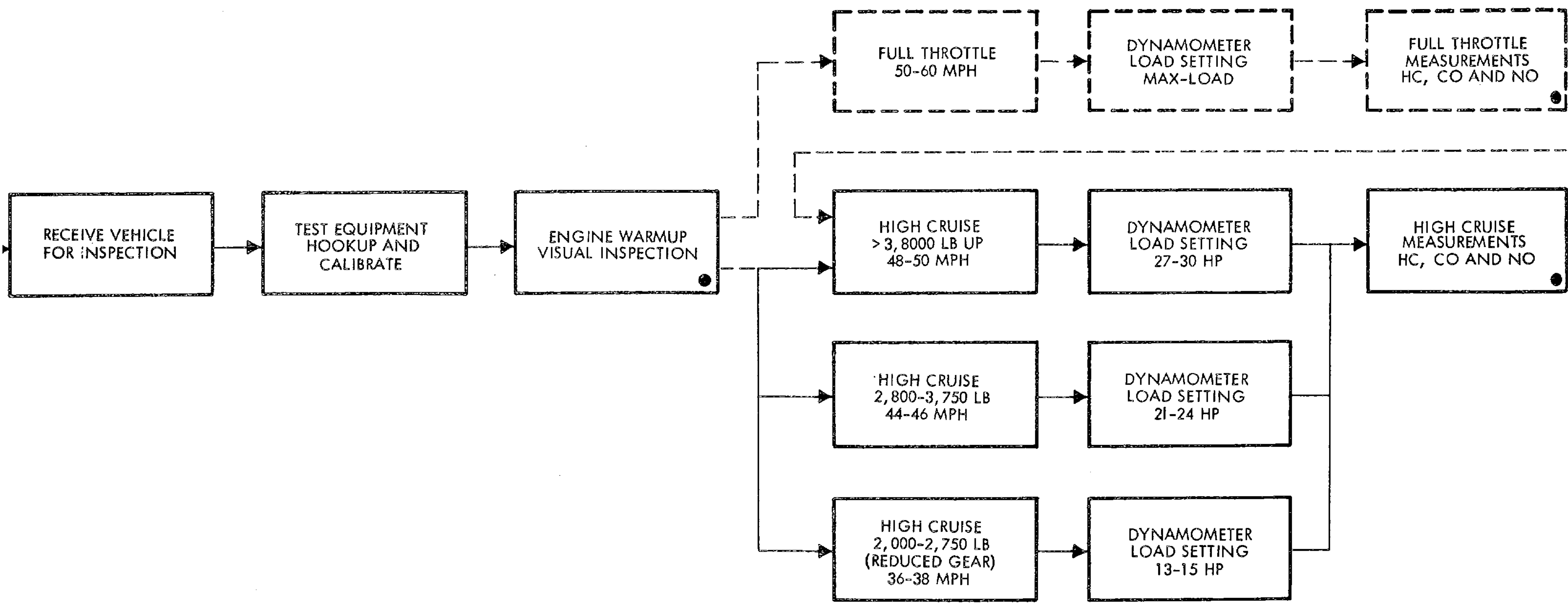
The Key-Mode test was developed by the Clayton Manufacturing Company. The test is performed on a simple chassis dynamometer at vehicle speed and load modes that are calculated to expose engine faults. The operational modes are high cruise, low cruise, and idle. After vehicle pretest activities are performed, the vehicle is positioned on the dynamometer and emission test equipment attached. The initial test mode is at high cruise conditions. The driver accelerates to a speed and load range of 44 to 50 mph and 21 to 30 hp, the specific speed and load depending upon vehicle weight. During this period the engine is allowed to temperature stabilize. High cruise emission measurements are performed and the vehicle speed and load is reduced to 22 to 30 mph and 6 to 12 hp, the specific speed and load depending again upon vehicle weight. After exhaust measurement, the vehicle is returned to idle for final measurements prior to post-test operations.

Figure 5-1 illustrates the general test procedure logic. The high cruise mode provides a dynamic test of the carburetor main jet system, the ignition advance system, and the secondary ignition wiring system under approximately maximum power conditions. The low cruise mode is a transition area between idle and high cruise. The carburetor system is blending the idle and main jet circuits and the vacuum ignition advance is in full operation while mechanical ignition advance is just beginning. Engine "stumble" coming off idle is highlighted in this mode. The idle mode provides a test of the basic engine adjustments of dwell, timing, carburetor idle speed and mixture. An optional full throttle maximum load mode is shown in dotted lines. This mode, if performed, would reveal certain load-related failures that the lighter load modes may not detect. Maximum load failures include breakdown of spark plugs and wiring systems that may be marginal and go undetected by the high cruise mode.

These key-modes were selected to identify common problems with a high degree of accuracy. The identification of these problems for the mechanic, as a function of the Key-Mode test results, is provided through the use of Key-Mode "truth charts" developed by the Clayton Manufacturing Company. The truth charts are comprised of a group of example "report cards," and a listing of the most probable causes of failure and precautions to be taken in making the repair. This diagnostic aid is provided to the garages in the form of an instruction manual. A copy of this manual is included in the Appendix, Volume IV. Alternative certification records for incorporating the Key-Mode report card system are discussed in paragraph 9.4 of this volume.

At present, the truth charts do not include the repair instructions for failures based on the measurement of NO; however, the procedures to identify malfunctioning NO devices are available.

Figure 5-1. KEY-MODE INSPECTION PROCEDURE



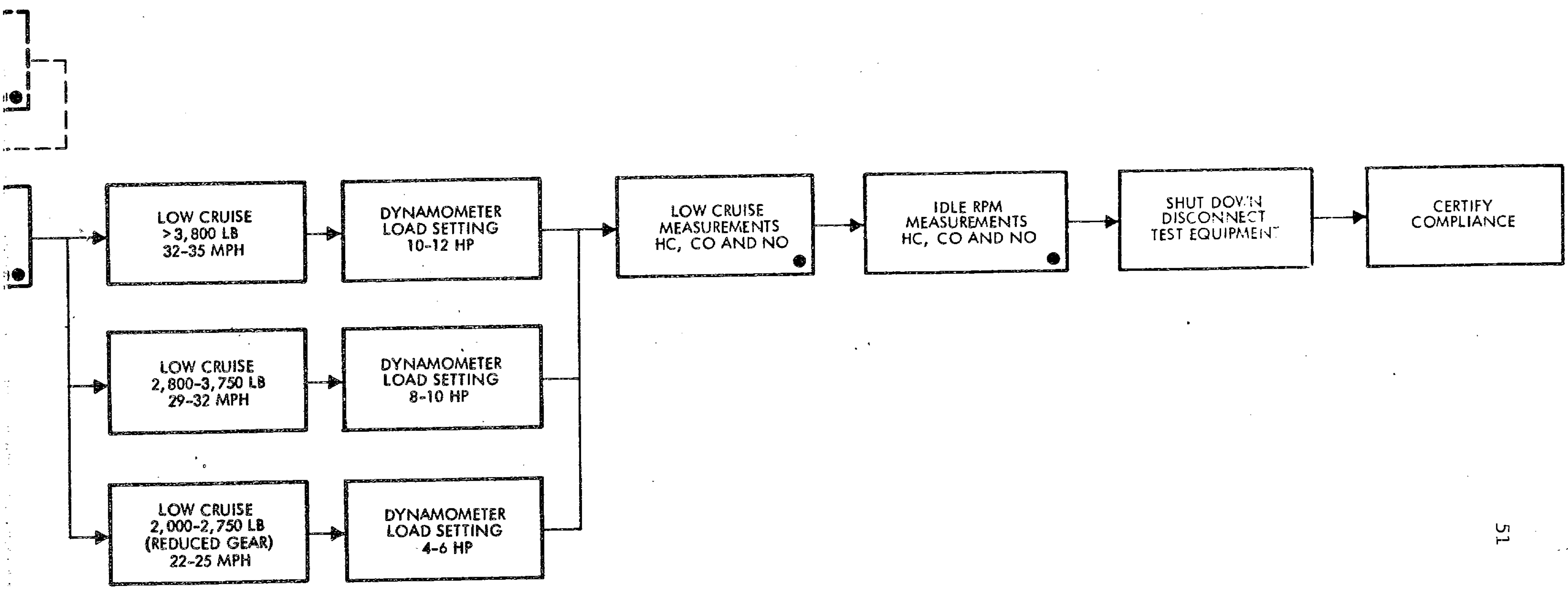

LOW CRUISE
>3,800 LB
32-35 MPH
DYNAMOMETER
LOAD SETTING
10-12 HP
LOW CRUISE
2,800-3,750 LB
29-32 MPH
DYNAMOMETER
LOAD SETTING
8-10 HP
LOW CRUISE
2,000-2,750 LB
(REDUCED GEAR)
22-25 MPH
DYNAMOMETER
LOAD SETTING
4-6 HP
LOW CRUISE
MEASUREMENTS
HC, CO AND NO
IDLE RPM
MEASUREMENTS
HC, CO AND NO
SHUT DOWN
DISCONNECT
TEST EQUIPMENT
CERTIFY
COMPLIANCE

Fig. 5-1 (cont.)

SECTION 6
INSPECTION STATION PERSONNEL AND FUNCTIONS

6.1 TYPES OF PERSONNEL

The personnel organization structure for a State-operated Key-Mode inspection station is shown in Figure 6-1 for a station of four-lane capability. The Key-Mode test regime requires one Level II technician and one Level I technician to perform the vehicle emission inspection requirements of a one-lane station. Both technician levels would be licensed by the State.

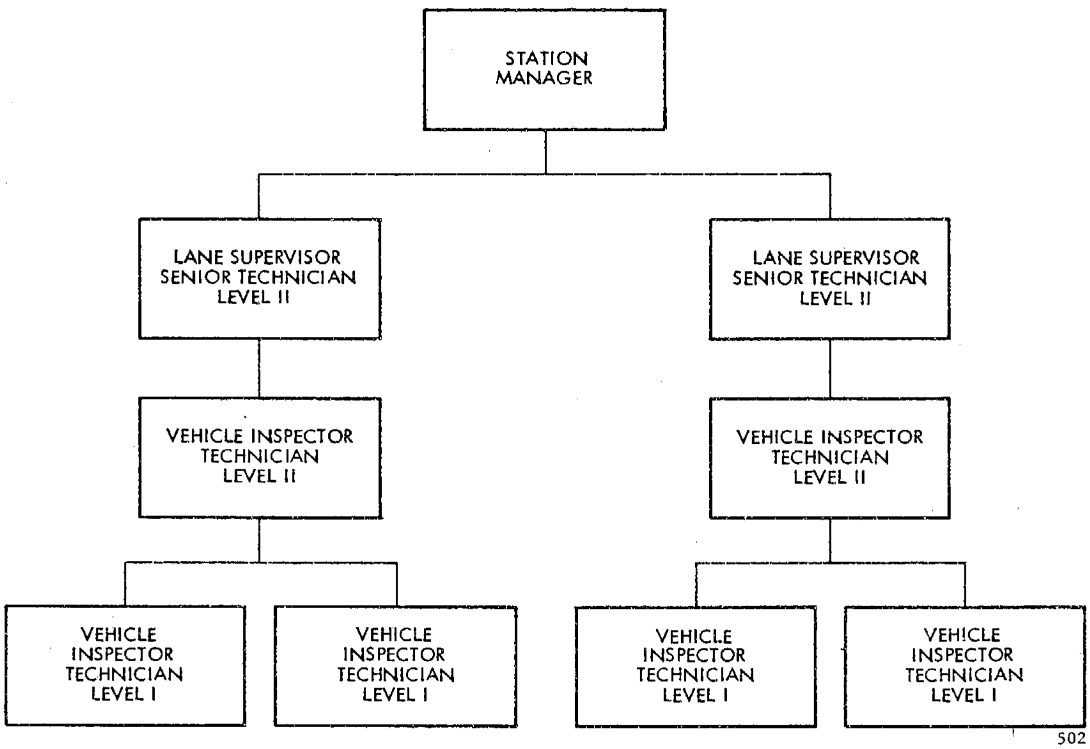


Figure 6-1. FOUR-LANE KEY-MODE INSPECTION STATION MANAGEMENT

The station manager would be a Senior Technician Level II with a minimum of 5 years experience. A Technician Level II inspector should have a minimum of 3 years of experience as a journeyman tuneup repair technician with some experience in the use of the ignition analyzer scope and the air-fuel ratio meter as diagnostic tools. He must have a high school education or the equivalent. Vocational auto or trade school training would be desirable.

Technician Level I should have 1 year as a tuneup technician with experience in removing, replacing, and adjusting ignition and carburetor components. Vocational auto or trade school training would be desirable in accordance with a specially designed Key-Mode training course as described below.

Technician Level II would receive an average wage of $7.56 per hour and Technician Level I would receive $5.79 per hour. Both rates include 25 percent in fringe benefits.

6.2 TRAINING PROGRAM

To assure the successful implementation of the Key-Mode test inspection regime, an effective comprehensive training program for the Level I and Level II Technician inspectors and instructor personnel is recommended. Existing public education facilities could be suitable to implement statewide inspector training programs on a continuing basis. The initial pilot training programs could be controlled better if conducted through private industry. These pilot programs would enable the formal course of inspection to be refined before general implementation.

The curriculum is designed to provide the student inspector and instructors with a comprehensive knowledge of the Key-Mode inspection regime and test operations, including instrumentation and equipment required for the inspection regime. The training course features classroom, laboratory, and on-the-job training in the following categories:

- Fundamentals of ignition and carburetion
- Emission control systems
- Key-Mode inspection and station operational procedures and equipment use.

The Key-Mode total training time requirement is 142 hours, distributed as follows:

Classroom lecture	39 hours
Laboratory demonstration	35 hours
"Hands on" training at the station	60 hours
Inspector certification	8 hours
	142 hours

If the training program classroom portion is incorporated into California's existing public education facilities, school laboratories would have to be equipped with Key-Mode inspection station instrument packages and dynamometers. Facilities with as many as four dynamometers are currently available through private industry for the implementation of the laboratory pilot program phase of training. Classroom training would be supplemented by on-the-job training at the inspection stations.

Accredited teachers would be selected as training instructors. Accreditation would require that they meet the Level III skill requirements. All instructors would be required to attend the Key-Mode inspection training class prior to their conducting the class. Initial training programs for instructors can be conducted by personnel already involved in the vehicle emission control and emission measurement training programs.

Technician Level III should have 5 full years as a journeyman tuneup repair technician with experience in repair and engine diagnosis utilizing ignition analyzer scope, air-fuel ratio meter, and the chassis dynamometer. He must have high school and vocational and/or trade school automechanics training. College level training is desirable and he must have a valid Class A Smog License.

6.3 PERSONNEL FUNCTIONAL CHARTERS

Figure 6-2 depicts the functional charters for the Level I and II inspectors and briefly outlines their responsibilities. The Level II inspector positions the vehicle on the dynamometer, connects the test equipment, conducts the Key-Mode inspection test, and removes the vehicle from the dynamometer. He is responsible for each class of vehicle. In addition, the Level II inspector quality-audits the emission data after the inspection test.

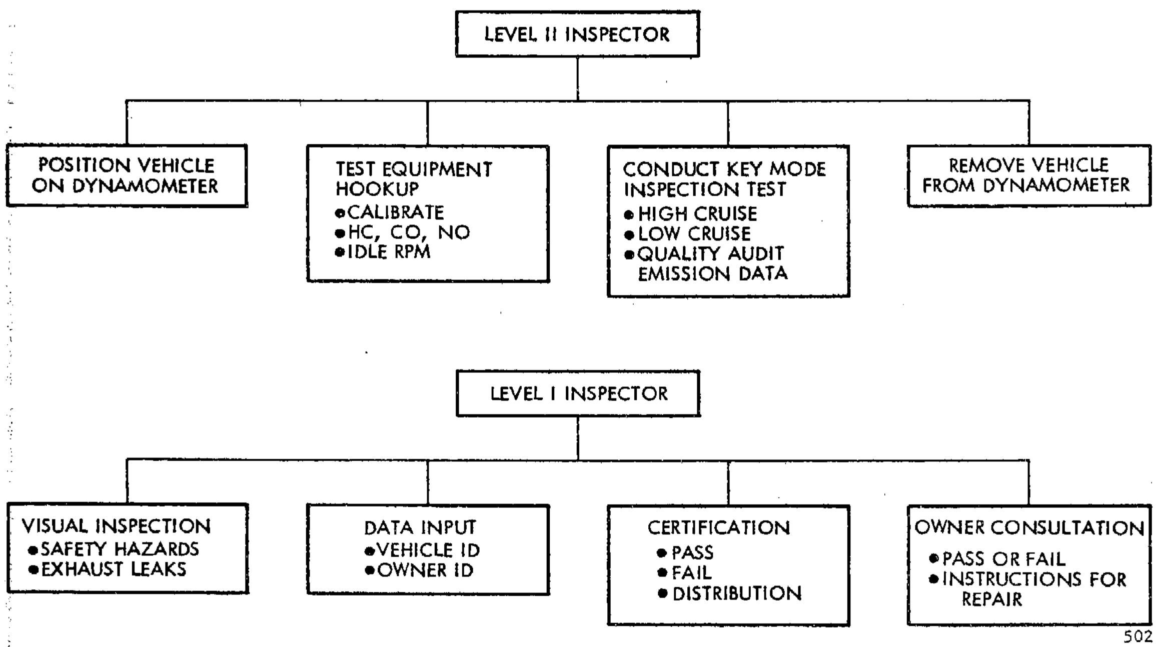


Figure 6-2. FUNCTIONAL CHARTER FOR KEY-MODE INSPECTION PERSONNEL

The Level I inspector visually inspects the vehicle, records and inputs the identification data, processes the certification, and advises the vehicle driver of the results. He is responsible for detecting obvious safety hazards and inspecting the exhaust system. After the car has been tested, the Level I inspector processes and distributes the certification papers. If the car fails the test, it is then the Level I inspector's responsibility to provide repair and reinspection instructions to the vehicle owner.

Both levels of inspection would be required to perform external and minor repairs on the test equipment. They would be responsible for maintaining an orderly station and maintaining all inspection records.

Station management would be conducted by the Senior Level II Technician in inspection stations of less than four lanes. In larger stations, specializing managers would be employed. Managers would coordinate the inspection personnel and maintain scheduled station operations.

SECTION 7
DESCRIPTION OF KEY-MODE FACILITY OPERATION

This section provides a narrative description of vehicle flow through the Key-Mode test inspection station and describes the inspection functions performed by the inspection personnel and equipment. The operation is based on a one-lane station configuration involving one dynamometer, two inspectors (Technician Levels I and II), and semiautomatic test and recording equipments. Figure 7-1 is a time-line functional flow of a test lane operation. Multiple lanes will follow this same pattern with only minor variations.

7.1 PRETEST INSPECTION

The sequence begins with the arrival of the first vehicle at the inspection station. The driver of the arriving vehicle, henceforth called the owner, drives the car into the pretest inspection area. Although the present inspection test configuration does not provide for a full safety inspection (though it easily could be incorporated), a safety inspection is required of those items affecting the accomplishment of the emission test. These items include condition of tires, radiator hoses, and exhaust system and excessive gasoline, oil, or water leaks. The owner will have been forewarned in a mailed inspection notice to check oil, water, gasoline, and transmission levels and tire pressure before arriving at the inspection station. A conspicuous sign reminding him of this requirement will be posted at the station entrance. The owner is also instructed by sign to turn on his headlights as he pulls into the pretest area. The Level I inspector (man 1) as a courtesy observes the proper functioning of headlights and brake lights (via mirrors) as the car comes to a halt.

The owner is instructed by sign to go through the sequence of events listed in Table 7-1. With the engine still running, the inspector uses a lighted mirror on rollers to inspect the undercarriage of the vehicle for exhaust system, fuel, oil and water leaks. Blocking of the tail pipe and listening for leaks also may be done. As the inspector progresses around the vehicle from right side to left, he notes tire wear condition and operation of parking, tail, license plate, and any side running lights.

Table 7-1. COURTESY SAFETY CHECK INSTRUCTION SEQUENCE

Item	Owner Action
1	Put car in neutral or park
2	Set hand brake
3	Headlights on (a) high beam; (b) low beam
4	Left turn signal
5	Right turn signal
6	Parking lights on

Registration data will be collected from the owner when the inspector reaches the left front door of the vehicle. Lifting the hood of the car, the inspector checks for installation or absence of the appropriate smog equipment; for gas, oil or water leaks; and notes any obvious items in need of service such as bad radiator hoses, corroded battery, or frayed wiring. The pretest inspection will take approximately 1.5 minutes.

Items that would impair the safe accomplishment of the emission test or result in questionable readings are brought to the immediate attention of the owner, with instruction to have them repaired and to return within an established time period. The car then will be exited from the test facility. Items not affecting the running of the test but which require attention are noted on an exception basis on the inspection check sheet or on a separate tear-off pad. These items are noted as a courtesy to the motorist and are not intended, by either direction or implication, to be an enforceable repair order. Should a comprehensive mandatory safety inspection be implemented, repair of some of these discrepancies would of course be required.

The owner is then instructed to leave his car and go to a waiting area. Man 1 inserts a preprinted card into a reader and enters any missing information. He then inserts the sample probe into the tail pipe after the Level II inspector moves the car onto the dynamometer. Man 1 then goes to the post-test area if there is a car awaiting certification or evaluation.

7.2 TEST OPERATIONS

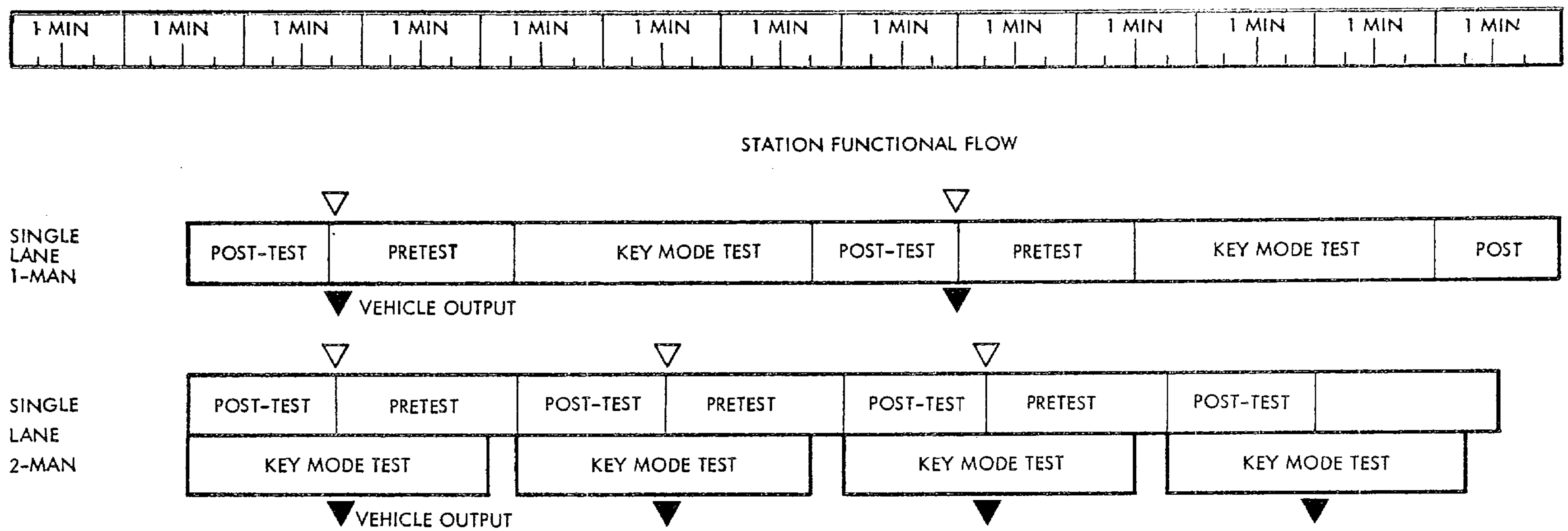
The Level II inspector (Man 2), having calibrated the test equipment, enters the car in the pretest inspection area, turns off the lights, and moves it forward onto the dynamometer. A retractable control box is retrieved and the test begun. The test inspector then drives the high cruise, low cruise, and idle modes using the control box to trigger automatic recordings for HC, CO, and NO at the appropriate time. On a signal from Man 2, Man 1 removes the sample probe from the tail pipe and retrieves the results from the recorder. Man 2 moves the car forward to the post-test area. Man 2 returns to the test equipment, purges the lines, recalibrates the instruments, and then goes to the next car waiting to be tested and moves it onto the dynamometer and the process is repeated.

7.3 POST-TEST OPERATIONS

Two possibilities exist during post-test operations. The car just tested is certified as having an acceptable emission level if it passed the test. If it failed, the results must be presented to the car owner with appropriate instruction for correction. Man 1 accomplishes the post-test functions and returns to the pretest area to service the next waiting vehicle.

7.3.1 Certification Recording

For passed cars, the owner is given a certified copy of the test results in the form of a Key-Mode report card (certification record), the courtesy safety inspection sheet, and a prepared brochure from the State and is sent on his way. A copy of the results is retained for forwarding to the Regional Office for data analysis purposes.



FUNCTIONAL FLOW SUMMARY TABLE

	SINGLE LANE		DOUBLE LANE	
VEHICLES PER HOUR	11.4	21.8	33.2	43.6
AVG TIME PER VEHICLE	5.25	2.75	1.8	1.37
SLACK TIME PER HR	0	5.5	0	11
TEST CREW SIZE	1	2	3	4

PRETEST TIME	1.5
TEST TIME	2.5
POST-TEST TIME (PASS)	.5
POST-TEST TIME (FAIL)	2.0
POST-TEST TIME (AVERAGE)	1.25

502

Figure 7-1. KEY-MODE SINGLE LANE STATION FUNCTIONAL FLOW

7.3.2 Corrective Maintenance Cycling

For cars failing the test, the owner will be given the courtesy inspection sheet and Key-Mode report card with failing-mode values documented. Preprinted instructions inform the owner to have appropriate repairs made and to return for certification within a specified period of time. The waiting room area will have conspicuously posted placards explaining the Key-Mode test and service procedure so that the owner can compare his car's failure modes with the examples to determine the service required. He may then perform the repair himself or have the work done by a Class A station and return for retest with proof of repair as provided by parts and/or labor receipt. Subsequent vehicle failure would be handled in accordance with the special procedure described in Section 9.

SECTION 8
INSPECTION STATION TYPES AND LOCATIONS

Key-Mode inspection station types and locations have been projected statewide on the basis of vehicle population center densities and the number of vehicles that can be processed per year by a Key-Mode test lane. A one-lane station with two inspectors can process 25,000 vehicles per year, and includes $15,000 worth of equipment. A two-lane station can process 50,000 vehicles per year with four inspectors and $30,000 worth of equipment. The station capacity increases linearly with the number of lanes. Mobile facilities also could be provided. Although equipped and staffed the same as a single lane station, mobile facilities were estimated to be able to process one-fourth the number of cars that a stationary site could process.

The geographic distribution of stations that would be required for 100 percent implementation of a State-operated periodic inspection program based on the Key-Mode test is shown in Figures 8-1, 8-2, and 8-3.

A summary of selected vehicle emission test center sites is presented in Table 8-1. This listing identifies the stations by number of lanes alloted to a given site. The sites are located only in terms of the municipality or unincorporated area to which they have been assigned. In some instances, the estimated vehicle population of a given site is too large to warrant a single station. A notable example is Los Angeles City proper which has been assigned 39 lanes. No more specific assignment of station type for this or any other station site so identified would be prudent without analysis of vehicular traffic flow and local land availability. Wherever two or more municipalities are designated for one station, the specific recommended site is indicated in Table 8-1 with an asterisk. For example, in the South Coast Basin, the cities of Alhambra, Monterey Park, and San Gabriel would be assigned one four-land station for which the recommended location is Alhambra.

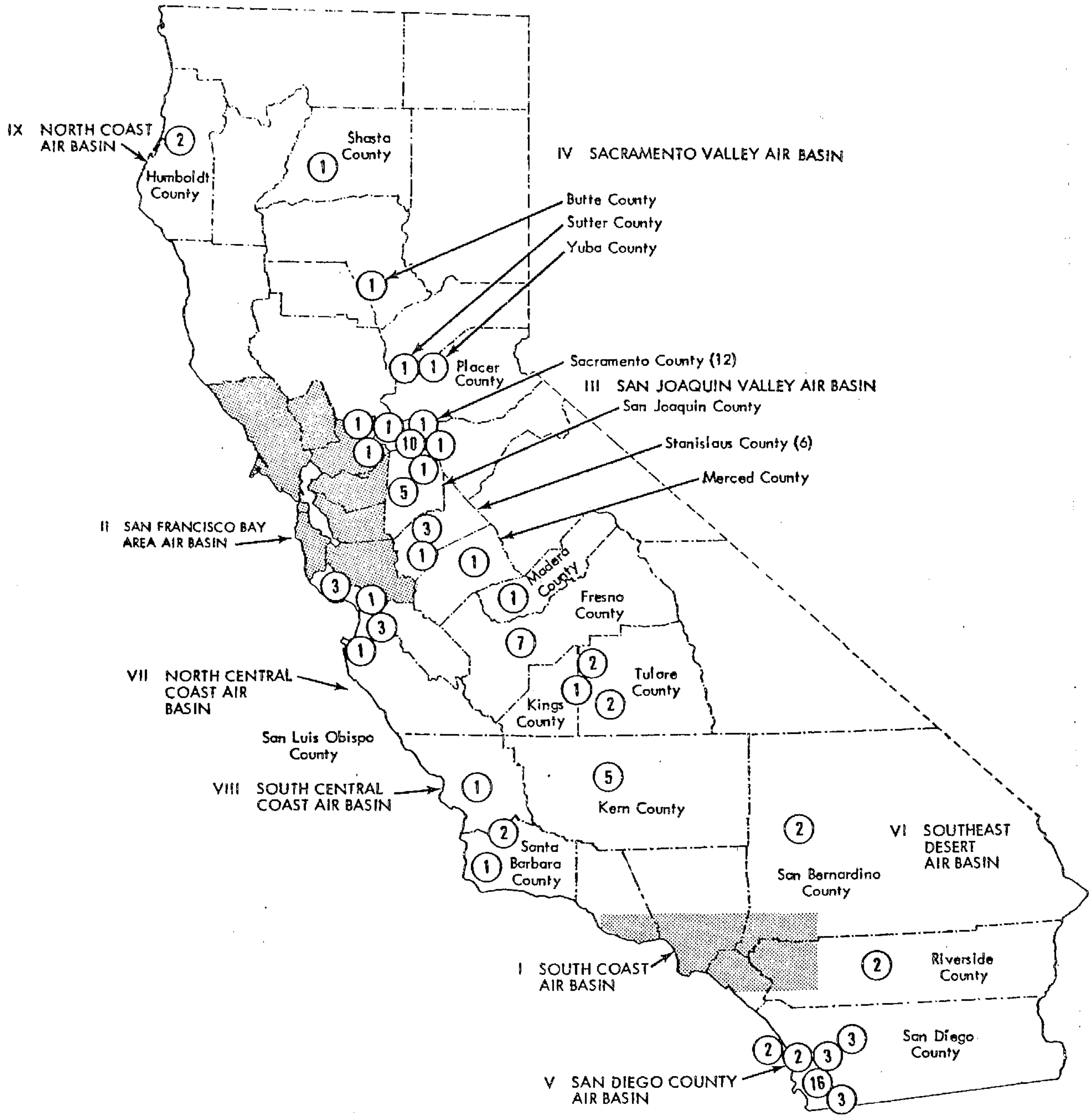


Figure 8-1. GEOGRAPHIC DISTRIBUTION OF STATE-OPERATED KEY-MODE INSPECTION STATIONS

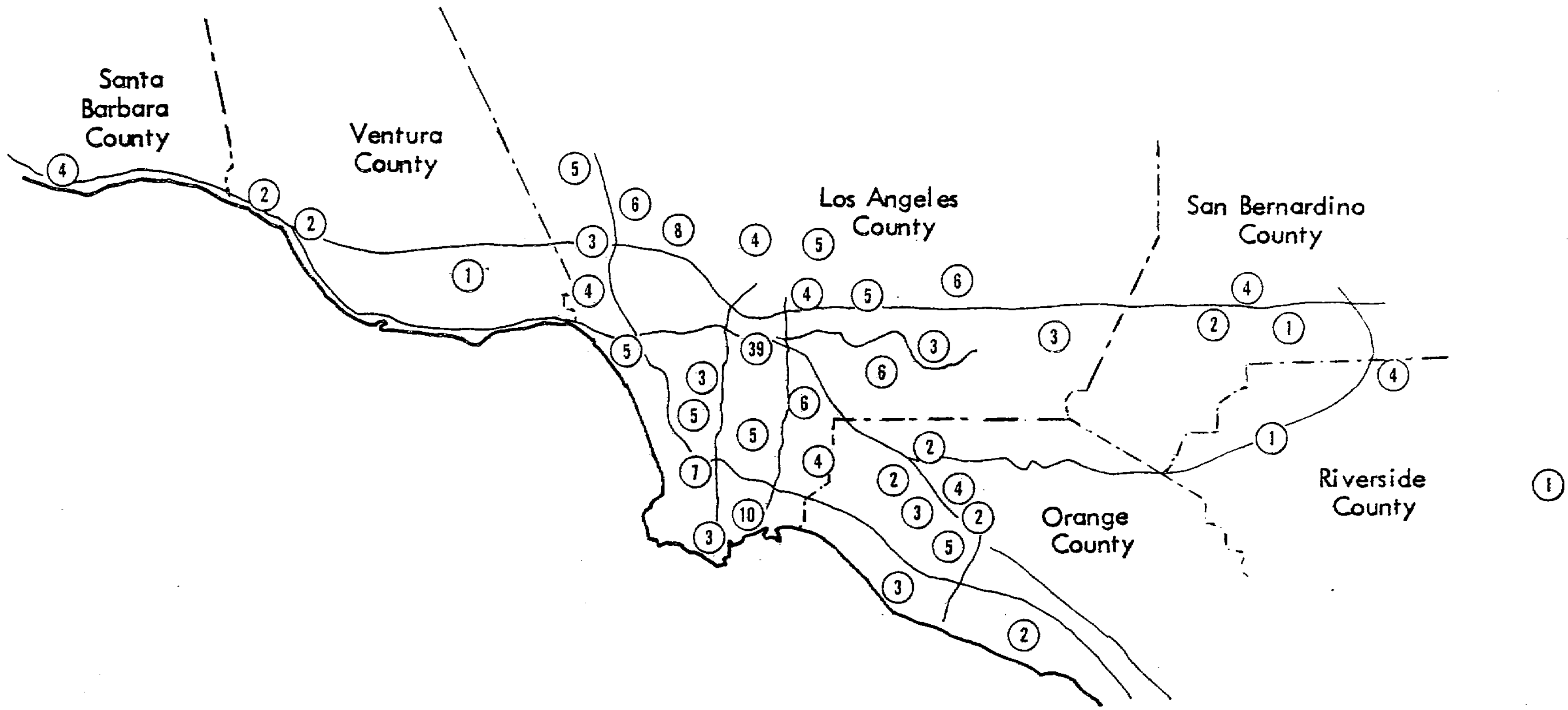


Figure 8-2. GEOGRAPHIC DISTRIBUTION - SOUTH COAST AIR BASIN

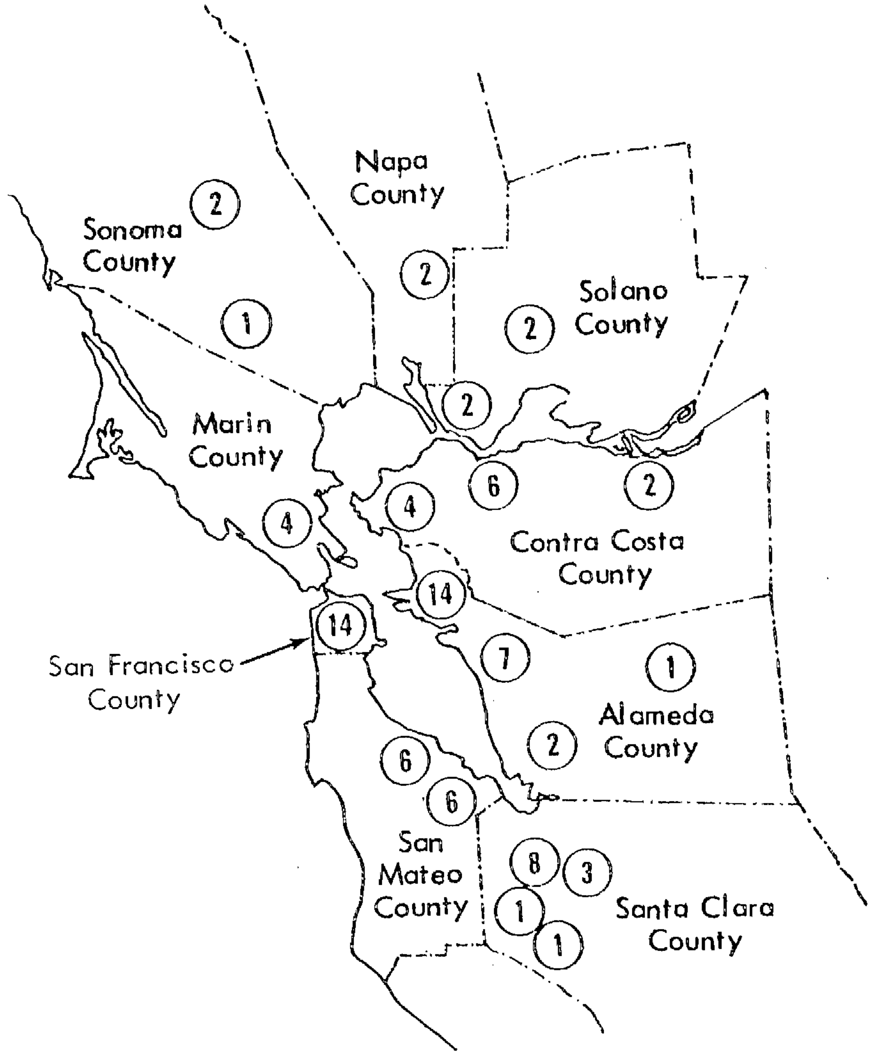


Figure 8-3. GEOGRAPHIC DISTRIBUTION - SAN FRANCISCO BAY AREA AIR BASIN

Table 8-1. SUMMARY OF INSPECTION LANES AND LOCATIONS

Vehicle Population Center	Lanes
I. SOUTH COAST AIR BASIN	
Los Angeles County	
*Alhambra Monterey Park San Gabriel	4
*Canoga Park Woodland Hills	4
*Compton Lynwood Southgate	5
*Downey Bell Norwalk Paramount	6
*El Monte Arcadia Monrovia Temple City	5
Glendale	4
Hawthorne *Gardena Manhattan Beach	5
Inglewood	3
*Lakewood Artesia Bellflower	4
La Puente	3
Long Beach	10
Los Angeles	39
North Hollywood *Burbank Sun Valley	8
*Northridge Reseda	3
Altadena *Pasadena South Pasadena	5
*Pomona Claremont	3
*San Fernando Pacoima	5
San Pedro - Wilmington	3
*Santa Monica Culver City Venice	5

Vehicle Population Center	Lanes
*Torrance Palos Verdes Peninsula Redondo Beach	7
*Van Nuys Encino	6
West Covina Azusa Baldwin Park *Covina Glendora	6
*Whittier Pico Rivera Montebello	6
Santa Barbara County	
Santa Barbara	4
Orange County	
Anaheim	4
Buena Park	2
Costa Mesa	2
Fullerton	2
Garden Grove	3
Huntington Beach	3
Orange	2
Santa Ana	5
Riverside County	
Riverside	4
Corona	1
Hemet	1
San Bernardino County	
San Bernardino - Redlands	4
Ontario - Upland	2
Rialto	1
Ventura County	
Ventura	2
Oxnard	2
Thousand Oaks	1
TOTAL	194

Table 8-1. SUMMARY OF INSPECTION LANES AND LOCATIONS (Continued)

Vehicle Population Center	Lanes
II. SAN FRANCISCO BAY AREA AIR BASIN	
Alameda County	
Fremont	2
*Hayward San Leandro San Lorenzo	7
Livermore	1
*Oakland Berkeley Alameda Lafayette (Contra Costa County)	14
Contra Costa County	
*Antioch Pittsburg	2
*Concord Martinez Walnut Creek	6
*Richmond El Cerrito	4
Marin County	
*San Rafael Mill Valley Novato San Anselmo	4
Napa County	
*Napa St. Helena	2
San Francisco County	
San Francisco	14
San Mateo County	
*Daly City Pacifica San Bruno South San Francisco	6

Vehicle Population Center	Lanes
*Redwood City Palo Alto (Santa Clara County)	6
*San Mateo Burlingame Millbrae Belmont	6
Santa Clara County	
Los Gatos	1
*Santa Clara Campbell	3
Saratoga	1
*Sunnyvale Cupertino Los Altos Mountain View	8
Solano County	
Vallejo	2
*Fairfield Vacaville	2
Sonoma County	
Santa Rosa	2
Petaluma	1
TOTAL	94
III. SAN JOAQUIN VALLEY AIR BASIN	
Fresno County	
Fresno	7
Kern County	
Bakersfield	5
Kings County	
Hanford	1

Table 8-1. SUMMARY OF INSPECTION LANES AND LOCATIONS (Continued)

Vehicle Population Center	Lanes
Madera County	
Madera	1
Merced County	
Merced	1
San Joaquin County	
Lodi	1
Stockton	5
Stanislaus County	
Modesto	3
Turlock	1
Tulare County	
Porterville	2
Visalia	2
TOTAL	29 (plus 8 mobile)
IV. SACRAMENTO VALLEY AIR BASIN	
Butte County	
Chico	1
Placer County	
Roseville	1
Sacramento County	
Carmichael	1
Citrus Heights	1
*Sacramento West Sacramento	10
Shasta County	
Redding	1
Sutter County	
Yuba City	1
Yolo County	
Davis	1
Woodland	1
Yuba County	
Marysville	1
TOTAL	19 (plus 10 mobile)
V. SAN DIEGO AIR BASIN	
San Diego County	
San Diego	16
La Mesa	3
El Cajon	3
Escondido	2
Oceanside	2
Chula Vista	3
TOTAL	29
VI. SOUTHEAST DESERT AIR BASIN	
San Bernardino County	
Barstow	2
Riverside County	
Palm Springs	2
TOTAL	4 (plus 10 mobile)
VII. NORTH CENTRAL COAST AIR BASIN	
Monterey County	
Monterey	1
Salinas	3

Table 8-1. SUMMARY OF INSPECTION LANES AND LOCATIONS (Continued)

Vehicle Population Center	Lanes	Vehicle Population Center	Lanes
Santa Cruz County		IX. NORTH COAST AIR BASIN	
Santa Cruz	3	Humboldt County	
Watsonville	1	Eureka	2
TOTAL	8	TOTAL	2
	(plus 4 mobile)		(plus 4 mobile)
VIII. SOUTH CENTRAL COAST AIR BASIN		X. NORTHEAST PLATEAU AIR BASIN	
San Luis Obispo County			(2 mobile)
San Luis Obispo	1	XI. GREAT BASIN VALLEY AIR BASIN	
Santa Barbara County			(1 mobile)
Lompoc	1		
Santa Maria	2		
TOTAL	4	TOTAL ALL BASINS	398
	(plus 8 mobile)		

*Recommended Site

SECTION 9
PROGRAM MANAGEMENT

The overall management plan for the inspection and maintenance program is described in this section in terms of the staged implementation plan presented in Section 10. A fundamental recommendation of this study is to combine administrative and management of the Class A stations and the State-operated inspection facilities under a single program management agency within the State government.

This agency would be organized to provide overall program management centrally, with directly reporting regional management offices in each of the 11 California air basins. An organization chart reflecting the overall control management structures and that of a representative regional office is shown in Figure 9-1. The State Program Management Agency would be responsible for the overall coordination and control of the program through the five functions shown. Regulation of Class A stations and State-operated stations would be delegated to the regional offices. This management structure consolidates management and control of the privately operated licensed stations and the State-operated stations under a single, responsible agency. This management structure should ensure uniform achievement of station performance standards among all participants. The standardization of management systems and procedures thereby achieved should provide efficiency and economy in program operations.

9.1 PROGRAM MANAGEMENT AGENCY

One State Program Management Agency, through an administrator, would be responsible for planning and managing the vehicle emission inspection and maintenance program. This responsibility would include specification of the inspection test regime, implementation, planning and scheduling, training and licensing of inspection and repair stations and personnel, overall program cost and schedule control, and general administration. The agency also would be responsible for establishing the exhaust emission failure limits for the pollutants of concern, the numbers of vehicles to be tested annually, the policy on vehicle retest after service, and the obligations of vehicle owners and repair garages should a vehicle fail the second emission test. The program office would also be responsible for establishing and maintaining liaison with other State and local agencies which interface with the program (for example, DMV, CHP, ARB, Business and Transportation Agency, and local air pollution control districts).

The agency also would be responsible for developing specific legislative proposals to expedite program implementation. This legislation may involve regulating repair garage rates and practices to develop uniform and fair procedures. Other legislation might exempt some regions of the State, depending on their vehicle population from periodic vehicle inspection. Legislation may be required concerning the scheduling of vehicles for inspection and maintenance may require new licensing and registration procedures to expedite the processing of vehicles through the inspection and maintenance functions.

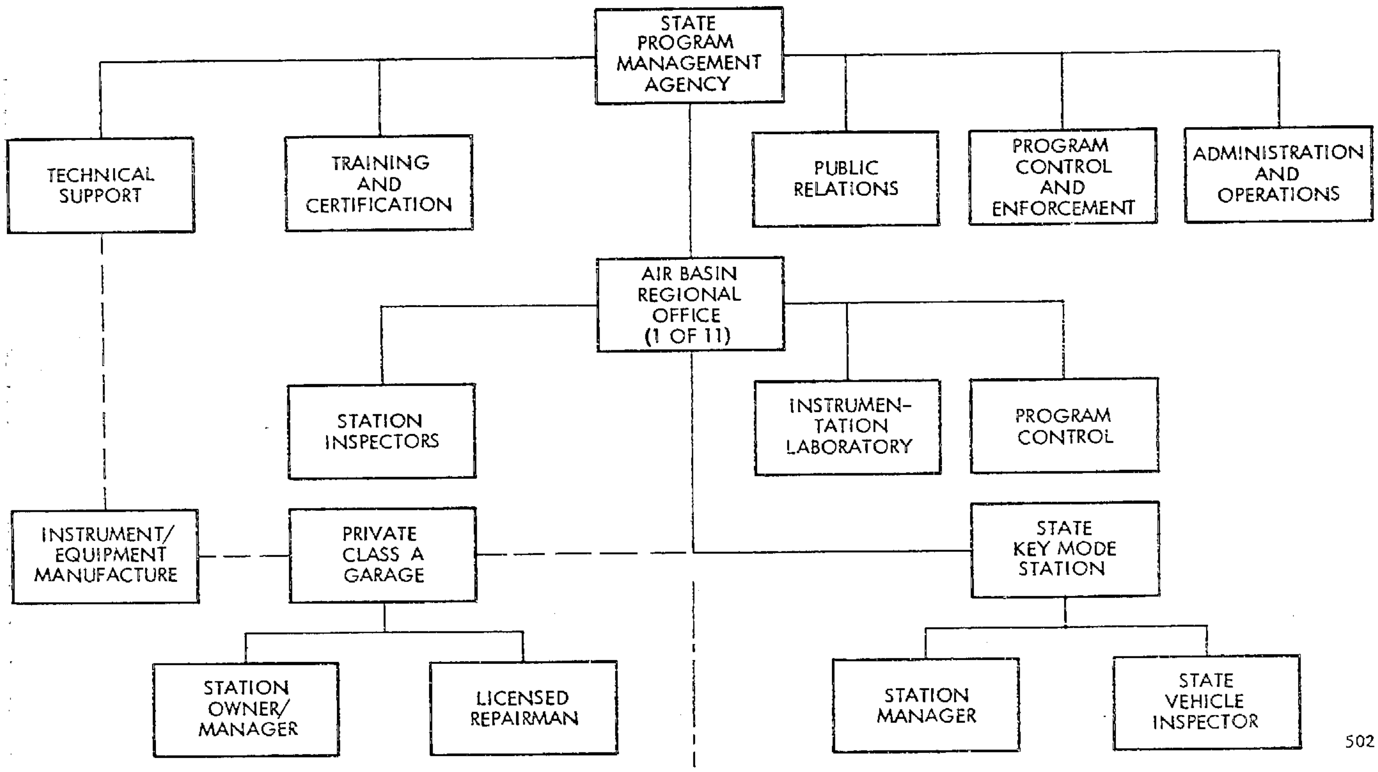


Figure 9-1. RECOMMENDED PROGRAM MANAGEMENT STRUCTURE

Because of the extensive technical and economic analysis required to initiate a practical program, it is suggested that the initial program planning work be contracted in part to private industry. Specific areas in which private contractors can contribute would be in data collection, development, and analysis on the technical requirements discussed in the preceding paragraphs, the implementation of training programs, and assistance with advanced technology studies.

The recommended State Program Management Agency contains five staff functions. These are a technical support office, a training and certification office, an enforcement and program control office, an administration and operations office, and a public relations office.

9.1.1 Technical Support Office

This office would provide the program administrator with recommendations for instrumentation, measurement and repair procedures, application and effect of new legislation, feasibility of new driving or test cycles, feasibility of new emission control devices, emission failure limits for the various model years of vehicles, and certification of applicable test instruments for use in inspection and repair facilities.

9.1.2 Training and Certification Office

This office would be responsible for establishing a uniform statewide curriculum for inspection and repair personnel. It also will be responsible for establishing uniform personnel licensing procedures and for developing manuals for personnel performance and performance testing. The training office would be responsible for preparing and publishing guides on inspection and repair practices which would be used by the field personnel. The training and certification office would establish the initial training programs and conduct the classes for implementing the program. After program implementation, a series of continuing classes could be established in the public and trade schools using the adopted State curriculum. Following the courses, personnel would be examined and then licensed according to procedures established by this office.

9.1.3 Enforcement and Program Control Office

This office will ensure that the overall program cost-effectiveness remains high. Data on vehicle emissions would be forwarded to the enforcement office for statistical analysis and review. Stations which report a high percent of passing vehicles would be subject to additional surveillance. Data would be compiled regarding performance of various emission control systems and the ability of repair garages to maintain their performance. The enforcement office would maintain a small staff of inspectors who would make spot checks on stations and repair garages to ensure that the regional facility compliance inspectors were performing to standards.

9.1.4 Administrative Office

This office would provide routine support services to the statewide program. The administration group would be responsible for maintaining current inventories of needed supplies, hiring personnel, publishing and distributing documents, maintaining liaison with other responsible agencies, payroll, salary and promotion reviews, and personnel transfers. The administration group also would be responsible for advanced planning and preparing advisory documents for circulation to other government agencies.

9.1.5 Public Relations Office

This office would be responsible for advising the public of the objectives of the inspection and maintenance program, the responsibilities and obligations of the vehicle owner and repair garage and annual reports on the status of the vehicle emission control program. Penalties for noncompliance by vehicle owners and fraudulent or unsatisfactory work by repair facilities would be clearly communicated to both the owners and the repair facilities.

9.2 REGIONAL PROGRAM MANAGEMENT

The principal staffing of the program is distributed throughout the State. Operating from regional offices located in the largest city of each air basin, regional administrative offices could be incorporated within other State offices if existing space is available.

Regional management would be assigned responsibility for implementing procedures established by the Program Administrator. The regional office would provide equipment and personnel support for individual inspection stations, provide periodic surveillance and continuing certification of each inspection station and its personnel, and provide for mobile inspection stations as required. Regional management also would be assigned responsibility for inspecting the Class A stations and for ensuring that their personnel are duly trained, licensed, and performing satisfactory work. Should vehicles repaired by a single garage consistently fail retest, the repair garage would be subject to inspection and performance testing of personnel. Garages which are repeatedly poor performers would be subject to revocation of license and the owners and repair personnel would be subject to personal fine if fraudulent behavior were proven. Regional program management has been divided into the following functional offices: (1) Regional Manager, (2) Station Inspectors, (3) Instrumentation Laboratory, and (4) Administration and Program Control.

9.2.1 Regional Manager's Office

The regional manager would be directly responsible to the program administrator for the inspection and maintenance program cost-effectiveness in his region. His performance would be judged by standards established by the administrator. The regional manager would have a staff to support the activities of the various field inspection stations and the participating private garages.

9.2.2 Station Inspectors

These inspectors would be responsible for periodically inspecting the State inspection stations and Class A stations to ensure that the respective facilities and personnel are performing satisfactorily to the specified standards. The inspectors would be empowered to reassign State inspection station personnel or to recommend their termination should they be found to perform unreliable or fraudulent work. The inspectors would be empowered to revoke a Class A station operator's license or the license of an individual repairman should either be found to consistently perform substandard, incompetent, or fraudulent work.

9.2.3 Instrumentation Facility

This facility would be staffed by trained technicians, skilled in repair and maintenance of the exhaust measurement instrumentation, data processing equipment, and dynamometers used in the various stations. The technicians would assist in calibration and maintenance of inspection instruments in the State stations, and provide assistance to the private stations if needed. They would be required to periodically (approximately 10 weeks) inspect each State inspection station and participating repair facility to provide on-site replacement of specific gas analyzer modules for return to the regional office for repair, recalibration, and realignment. The instrumentation facility ultimately would be responsible for accurate calibration and instrument performance in each region. The instrumentation technician would report to and be responsible to the regional manager.

9.2.4 Administration and Control

This function would be responsible for providing administrative support to the regional office, compiling records of garage operators, vehicle emission data, and vehicle certifications. The administrative office would be responsible for scheduling State inspection station tests and retests, assigning personnel to inspection stations, scheduling visits of facility compliance inspectors and instrumentation technicians to the inspection and repair facilities.

9.3 PROGRAM ADMINISTRATION AND ENFORCEMENT

The smooth functioning of the vehicle inspection and maintenance program would require cooperation among the various State agencies involved in administration, technical support, and enforcement. The program could be implemented using annual vehicle license renewals through the Department of Motor Vehicles. Using the vehicle license number, the vehicle owner would be scheduled for vehicle inspection before the end of a given month according to the last digit on his vehicle's license. The Program Management Agency's Public Relations Office would provide a circular to be mailed by the DMV along with registration application and fee card. The circular would describe the objectives of the inspection program and identify the inspection stations in the vehicle owner's general region. The vehicle owner must provide the valid certification document to the DMV at the time of registration. The DMV would then process the registration application as usual.

If the owner does not provide the certification document by the end of his registration period, the owner's registration would not be renewed. The owner would then become subject to citation for operating an unregistered vehicle.

When the vehicle owner takes his vehicle in for inspection, an emission measurement would be made to determine whether the vehicle's exhaust emissions were within the required limits. If the vehicle passed the inspection, the vehicle would be certified as passing. The vehicle owner would then return the certification document to the DMV at the time of registration.

Vehicles which are determined as failing the emission inspection would be required to be repaired prior to the registration. After the indicated service is performed, the emission measurement would be repeated. If the emissions are satisfactory, the vehicle would be certified as acceptable. If the vehicle were to fail the retest, the adequacy of the repair action would be investigated by a regional inspector. If the repair was erroneously made by the garage, the garage would be required to take remedial action based on the cost differential of the original erroneous repair. If the repair was correct for the inspection test results provided to the garage, the further repair action would be evaluated as to cost impact on the vehicle owner. In severe cost cases where the owner would face hardship due to the cost of ultimate repair, the inspector would have the option of approving the vehicle for one year of continued operation. Specific standards for this option would be required. Such vehicles would not be reregistered the next year if they continue as high emitters.

Vehicles which are sold during the registration period would be subject to inspection prior to transfer of ownership, using the same inspection operational procedures as for periodic inspection.

9.4 CERTIFICATION RECORDS

Inspection station operations will encompass the inspection test processing of vehicles through pretest, test, and post-test phases. The inspection process will culminate for any one inspection cycle in the issuance of a Certification Record (or a Key-Mode report card) to the vehicle owner. Certification would be issued only if the vehicle passes the exhaust emission test and, if included, the safety check. If the vehicle fails, the report card would show the test results for each operating mode. The vehicle owner then would be required to have the vehicle repaired and certified within a stated period of time.

9.4.1 Requirements and Alternative Solutions

The certification program has two basic requirements; these are:

a. To provide data to the State for statistical and enforcement purposes

b. To provide information to the mechanic in the Key-Mode report card format to ensure effective repair of a failed vehicle.

A secondary consideration is to provide the vehicle owner with a record of results when his car passes the emission test.

These requirements then take on two forms, a machine-readable document and a man-readable document. The final selection of the recording media will be accomplished during the system design phase of the inspection program implementation. This will ensure inspection system, intraagency, and interagency compatibility of automated data handling. Several alternatives are available:

a. Machine-printed output merged with preprinted vehicle ID data on microfilm for Optical Character Recognition (OCR) computer input

b. Machine-printed output to car owner and mechanic with manual or automatic merging of vehicle ID data and magnetic tape output to the State

c. Punched and printed card output merged with prepunched input, punched card results to the State with manual recording of results on punched output card for failed cars

d. Manual recording for both car owner and State.

The first alternative would be the most efficient but State data processing equipment may not have the capability for OCR microfilm input. The third alternative, though slower and not very efficient, does have the advantage of readily available computer input devices. To illustrate the certification process this third alternative will be discussed.

9.4.2 Example of the Certification Process

The basic certification document used is a two-part standard punch card, as shown in Figure 9-2. Use of the double card provides separate sections for the car owner and for the State in a convenient format. Blank cards would be available to replace those lost or damaged.

Prior to the test, any missing vehicle identification data are inserted on both halves of the double length card. As an alternative, identification data could be prepunched by the central State agency responsible for the inspection program and the card mailed to the car owner. This would facilitate control and scheduling of vehicle inspections. This information optionally can be inserted at the inspection station with the equipment specified, so that the process is not totally dependent on central control.

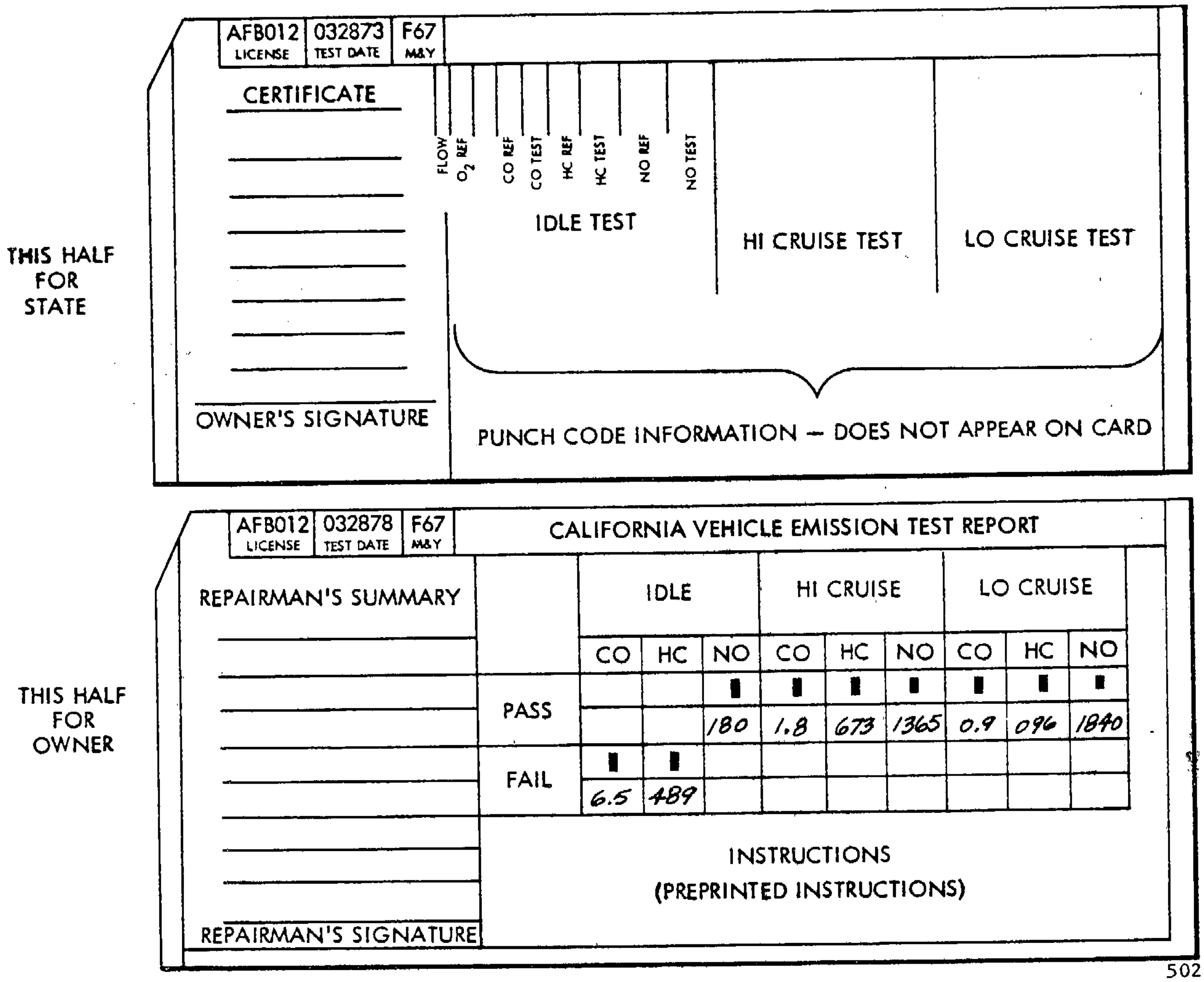


Figure 9-2. SAMPLE CERTIFICATION DOCUMENT

When the car is tested, the results of the test are recorded on the certification form. The information is also presented visually to the owner and to the maintenance mechanic who performs the maintenance if the car fails inspection. The visual presentation consists of punched holes in either a pass or fail position under each measured constituent in each test mode. To achieve the inherent effectiveness of the Key-Mode test, actual observed values are written in by the test technician. These values are critical to the evaluation of the "truth tables" which are used in conjunction with the Key-Mode inspection to effect repair action. The described system provides for insertion of these values manually, since equipment necessary to print them would add significantly to the cost. The capability can be provided, however, if desired.

That part of the card which is used to report the results to the State agency has all the identification and quantitative reference and test data inserted in computer-compatible format. The punched cards can be filed and sorted by standard punch card equipment. The information can be read into a central computer by telephone line, or the cards can be collected and mailed to the central control center. In either case, a central file of data will be generated which may be used for record purposes, for enforcement action, and for statistical analysis.

SECTION 10
IMPLEMENTATION PLAN

The plan for implementing mandatory vehicle emission inspection is an important output of the feasibility study. This plan is the means by which the feasibility analysis results are formulated into a practical program that is compatible with the emission reduction objectives of the State and with existing and projected programs for meeting those objectives.

Of foremost importance in formulating the implementation plan for the vehicle emission inspection and maintenance program is to achieve, as soon as possible, the emission reductions which the feasibility study has shown are obtainable. For maximum benefit, the program must be implemented within 1 year. This requirement is substantiated by the cost-effectiveness analysis, which shows that the maximum benefits occur through 1977. By that time, most of the pre-1966 uncontrolled vehicles will have phased out of use. As the newer, tightly controlled vehicles become predominant, the gross benefits decline.

The practical implementation of the vehicle emission inspection and maintenance program, within the shortest time span possible, requires an evaluation of the alternative inspection test regimes, both in terms of their implementation requirements and their compatibility with the short- and long-term requirements for vehicle exhaust emission control within the State. The most cost-effective inspection test regime may not be the most practical if it cannot be implemented in time to be of maximum benefit; or if it is of short-term benefit considering the overall State objectives and requirements.

10.1 STATE EMISSION CONTROL OBJECTIVES AND REQUIREMENTS

As noted above, the State of California has urgent short-term objectives to meet in the field of vehicle exhaust emission reduction as well as existing long-term objectives. Of immediate concern is the reduction in vehicle exhaust emissions that can be obtained with the implementation of a mandatory vehicle emission inspection and corrective maintenance program. To provide maximum benefit, the inspection test regime selected should first of all be implementable by 1972. Concurrently, the longer term requirements presented by the Clean Air Amendments of 1970 have to be considered.

There are two requirements of the Clean Air Amendments of 1970 that influence the selection of an inspection test regime and the plans for implementing vehicle emission inspection and mandatory maintenance. One is the warranty guarantee automobile manufacturers are required to provide on emission control devices once a suitable inspection system is found to exist and is promulgated by the Environmental Protection Agency. In line with California's lead in the field of air pollution control, consideration should be given in the selection of a mandatory vehicle emission inspection and maintenance program to an inspection system that will provide the basis for implementing manufacturer warranties on emission control devices in California.

econd area is the requirement for exhaust emission constant volume sampling measurement testing presented by the 1972 Federal Test Procedure, which has ı promulgated under the Clean Air Act. This requirement is related to the afore- tioned warranty inspection test system requirement in that the inspection test must be compatible with the Federal Test Procedure. Both of these requirements support the need for an inspection system that has dynamic test capabilities provided by the Key-Mode test.

10.2 RECOMMENDED INSPECTION TEST AND CORRECTIVE MAINTENANCE PROGRAM IMPLEMENTATION PLAN

To meet the short- and long-term objectives and requirements for California vehicle emission control, a threefold approach to implementing a mandatory program of inspection and corrective maintenance is recommended. This approach is based on the following considerations:

a. The difficulty of implementing a full-scale State-operated inspection program in time to be of maximum benefit

b. The long-term requirement to prepare for inspection test of manufacturer warranties on emission control systems under Federal Test correlatable procedures

c. The requirement to provide an optimum allocation of inspection test and corrective maintenance functions between the State and private sectors, based on the inspection test characteristics revealed by the cost-effectiveness analysis

d. The improved cost-effectiveness that can be achieved before 1980 by applying existing automatic test technology to vehicle emission inspection and maintenance requirements.

The approach encompassing these considerations is divided into a three-phase implementation program plan. The major task elements of this plan are shown in their general time relationships in Figure 10-1.

10.2.1 Phase I - Class A Station Program

This phase is designed to meet the immediate requirements for vehicle emission inspection and maintenance by utilizing and upgrading the existing capabilities of privately owned Class A licensed inspection and repair stations. This is the most practical way in which to implement a mandatory inspection and maintenance program in the earliest possible time frame. This program phase can be initiated in the 10 pollution-critical counties 5 months after program approval.

The potential of the existing Certificate of Compliance Inspection Test is not being realized because of the compromise that has been made between enforcement and compliance. The Part A Feasibility Study has shown that controlled management of an inspection test regime, as was possible with the Key-Mode and the Idle tests, can provide higher cost-effectiveness, if the test is designed to meet a corrective maintenance criterion. The Phase I implementation program recommended for the Certificate of Compliance is based on upgrading the existing compliance procedure to approach the cost-effectiveness of the Idle test. This approach takes advantage of the demonstrated cost-effectiveness of the Idle test and the existing availability of the Class A licensed stations.

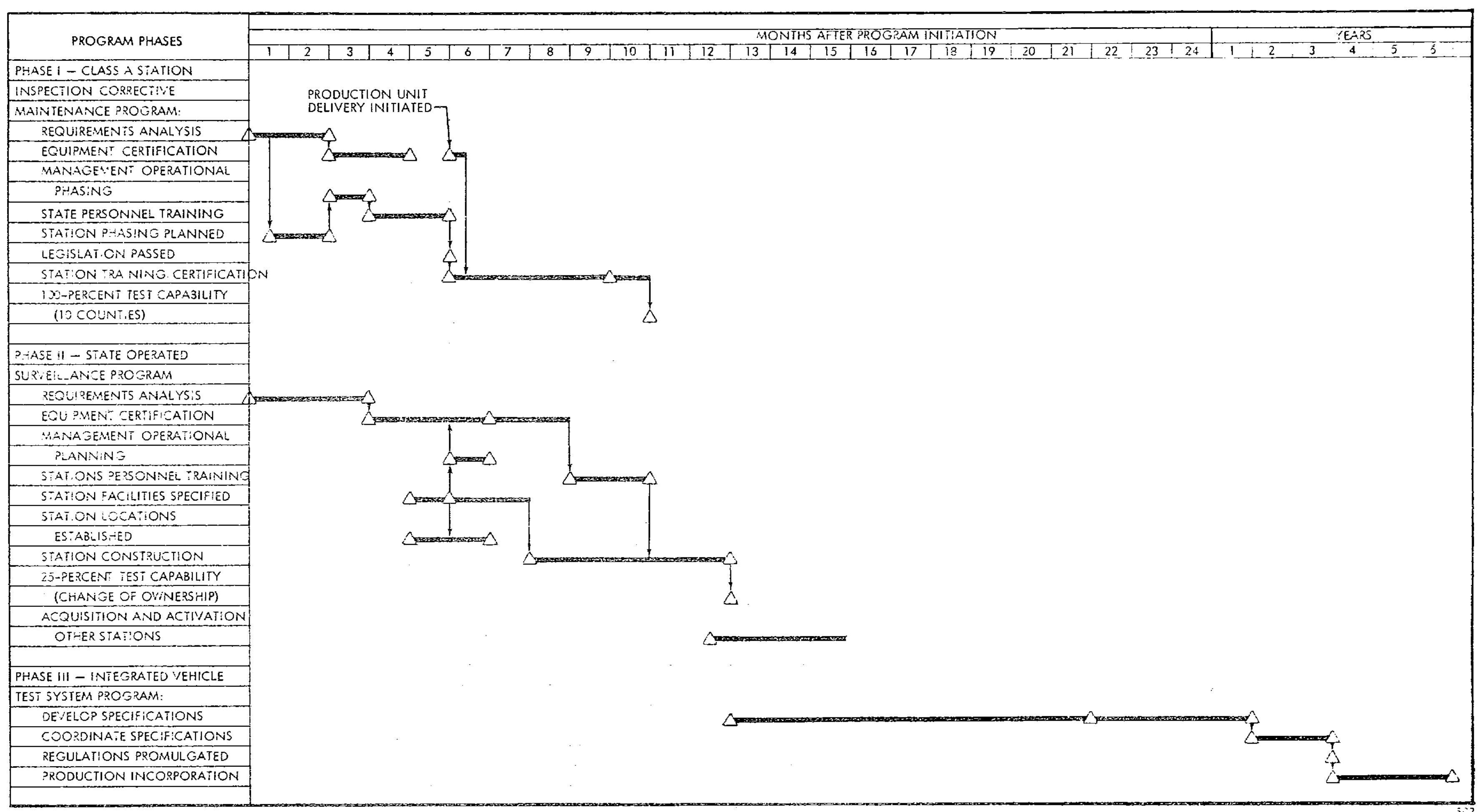


Figure 10-1. RECOMMENDED IMPLEMENTATION PROGRAM PLAN

The upgraded test would be based on the concept of incorporating the inspection and the maintenance phases into an integrated inspection/maintenance procedure. As in the Idle test, the procedure would begin with an emission level inspection which would determine whether the car is performing within acceptable emission limits. The results of this inspection would determine what corrective maintenance is required.

The implementation of Phase I is essentially a quick response designed to fill the gap until the time State-operated inspection stations phase into the program. The modified Certificate of Compliance - Idle test procedure will have a cost effectiveness ratio somewhere between the two procedures and well below that of the Key-Mode test. It lacks the desirable separation between inspection and maintenance functions which assures objective inspection and most economical maintenance. Participation by the privately owned stations must be induced by economic forces which may not be compatible with long-range program objectives. For example, if inspection fees in the Class A stations are set and controlled at the desired level by State regulation, operators may be motivated to conduct excessive repair functions to compensate for real or assumed losses in the inspection activity.

To assure private operator participation to the fullest extent, the test plan should incorporate only that instrumentation ultimately deemed essential for accomplishing the maintenance portion of the procedure. In practice, this means that only CO and HC measurements at the 5 percent accuracy level should be imposed, resulting in the possible necessity for setting failure limits somewhat higher than desirable for optimum application of the standard Idle test. By incorporating this provision, however, the Class A stations will not be required to invest in equipment which would exceed their long-term requirements for performing the important maintenance function of the overall inspection and maintenance program.

The principal tasks required to accomplish the modification of the Certificate of Compliance-Idle test and to prepare Class A stations to perform this test are identified and scheduled in Figure 10-2. As shown, activation of Class A stations to perform the modified test could be initiated 20 weeks after the Phase I program definition starts.

The analyses of the test procedure, instrumentation and equipment requirements, personnel requirements, training requirements, and facility and station location requirements are essential steps leading to the preparation of a Management and Operational Plan which can be used by the Air Resources Board to draft the necessary legislation. The principal tasks leading to this plan are summarized in the following paragraphs.

10.2.1.1 <u>Task I-1: Modified Certificate of Compliance-Idle Test Procedure</u> - The existing Certificate of Compliance and Idle test procedures will be analyzed to integrate their respective advantages for inspection and corrective maintenance. The objective will be to devise a test procedure that provides quick go, no-go identification of high emitters followed by error-free identification of the cause of high emission. The procedure will be designed for controlled management of both the initial emission level test and any subsequent corrective maintenance actions.

10.2.1.2 <u>Task I-2: Functional Analysis</u> - The test procedure will be analyzed to identify all functions required to perform it. These functions will include all of the discrete steps of activity from the time a vehicle owner is notified to present his vehicle for inspection, through the pretest, test, post-test, repair, retest,

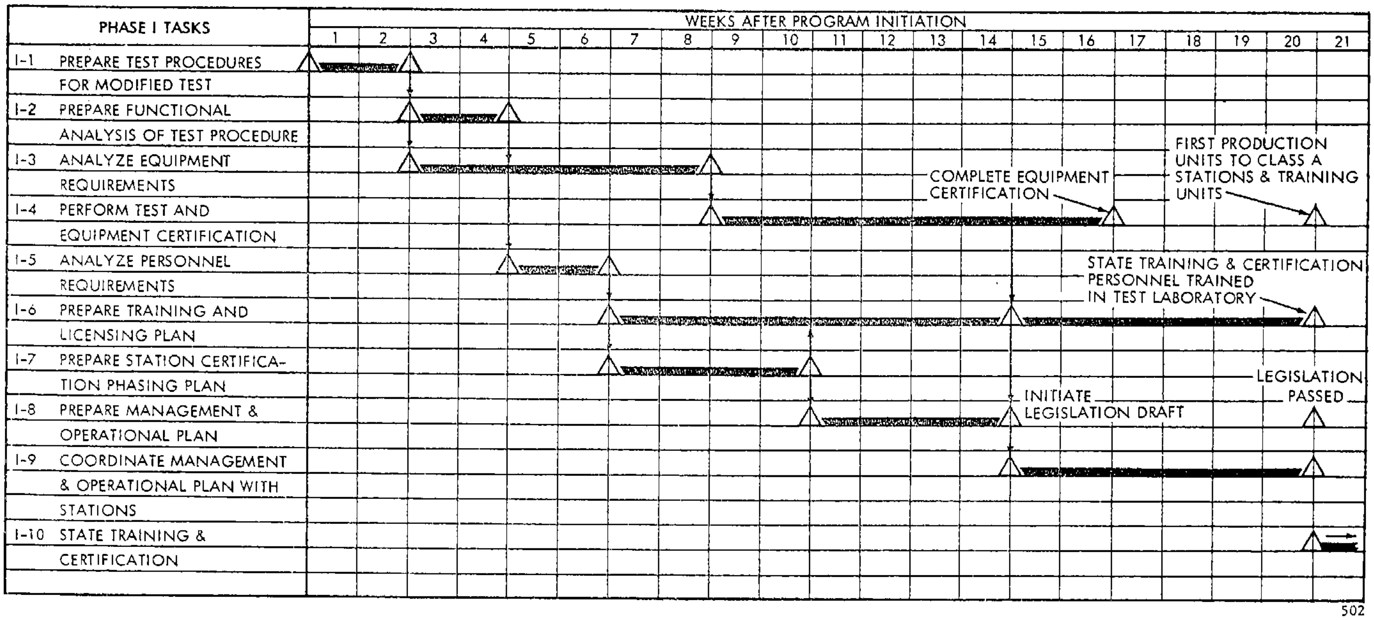


Figure 10-2. CERTIFICATE OF COMPLIANCE IDLE TEST PROGRAM PLAN

and certification phases, to the reporting of vehicle status to the State agency in charge of the program. The overall flow of functions will be depicted graphically in a block diagram showing the input-output relationship between functions. Each block will then be defined in terms of the specific work involved, the amount of time required to perform the work, and the method of work accomplishment.

This analysis will be used to derive the equipment, personnel, and training requirements in the subsequent tasks of this implementation plan.

10.2.1.3 Task I-3: Equipment Requirements Analysis and Performance Specifications - Instrumentation and equipment requirements will be determined by means of the functional analysis, based on the concept of manual inspection and maintenance. Performance specifications will be prepared and will be designed to allow the use of commercially available equipment to the greatest possible extent. This provision is essential to limit the investment cost to a level acceptable to Class A operators and to ensure the availability of adequate quantities of equipment at the time of implementation. Equipment found acceptable will be scheduled for certification.

10.2.1.4 Task I-4: Test Equipment Certification Program - Equipment and test certification will be conducted in a laboratory controlled environment which simulates a typical Class A station. The modified Certificate of Compliance-Idle test procedure will be used along with controlled test vehicles. Equipment suppliers will be notified whether their equipment is certified or not. Suppliers certified will be provided with the Management and Operational Plan (Task I-8) so that they may contact Class A stations for equipment installations.

This certification program will also be used to validate the personnel requirements analyses (Task I-5) and the training plan (Task I-6).

10.2.1.5 Task I-5: Personnel Requirements Analysis - Concurrent with the coordination of equipment requirements with suppliers, the functional analysis of the test procedure and the equipment requirements analysis will be used as the basis for a personnel requirements analysis. Personnel requirements will be analyzed for all management, operational, and training functions both at the State and the Class A station levels. For each personnel requirement, a functional description of his job will be prepared and the skill level will be defined along with the commensurate job classification and salary or wage range. The number of personnel required in each classification also will be determined.

10.2.1.6 Task I-6: Personnel Training and Certification - A survey of existing Class A stations will be conducted to obtain data on numbers and skill levels of their personnel. For each job classification a training plan will be prepared. For the technician classification, the plan will include the course of instruction required to operate the test equipment and to upgrade existing Class A station mechanics to the modified Certificate of Compliance-Idle test procedure. A training and certification schedule will be prepared based on the Station Certification Phasing Plan of Task I-7.

Upon the completion of the equipment and test certification program, the laboratory equipment setup will be used to train State personnel who will be responsible for training and certification of Class A station personnel. A sufficient number of State Certification Teams will be trained to support the station activation schedule for each air basin. These personnel would phase into inspector positions or into the State-operated Key-Mode inspection stations as Class A station certification is completed.

10.2.1.7 Task I-7: Prepare Station Certification Phasing Plan - A time-phased plan of Class A station relicensing and certification will be prepared. This plan will control the activation of relicensed stations on the bassis of vehicle population centers and air-pollutant-critical air basins. It is recommended that certification of stations be concentrated initially in the 10 counties presently approved by the California Health and Safety Code, Section 39176, for exhaust emission control retrofit devices.

10.2.1.8 Task I-8: Management and Operational Plan - The results of the functional analysis, equipment analysis, personnel requirements, training requirements, and station certification plan will be incorporated into an overall Management and Operational Plan.

The Management and Operational Plan will constitute a handbook for the entire Class A Station Inspection/Maintenance Program. It will document the test procedure, equipment and personnel requirements, training and certification requirements, vehicle certification data management requirements, and the statewide management plan. The nonrecurring and recurring costs of implementing the plan will be estimated.

10.2.1.9 Task I-9: Management and Operational Plan Coordination with Class A Stations - Concurrent with the drafting of legislation based on the Management and Operational Plan, the plan will be coordinated with those Class A stations which have been selected in Task I-9 to initiate the program. This coordination will orient the stations in the requirements and time schedule for certification.

10.2.1.10 Task I-10: State Training and Certification - After legislation is passed, State personnel trained as instructors and inspectors as part of Task I-6 would operate as mobile teams in assigned air basins to train and certify Class A station personnel in the modified Idle test Inspection and Maintenance Procedure. Prior to certification, Class A station owners would be required to obtain equipment as required by the Maintenance and Operational Plan. Training classes could be conducted on a community area basis in the evenings and weekends. Certification, however, would require station on-site inspection of the facility, equipment, and personnel by State inspector personnel.

State personnel employed in these training and certification activities will be phased into the State-operated Key-Mode stations as the Class A station training and certification program is completed.

10.2.2 Phase II - State Surveillance Program

With respect to the considerations noted in paragraph 10.2 for a statewide mandatory inspection and maintenance program, this program phase is designed to prepare the State for the long-term requirements for surveillance of manufacturer warranties on vehicle emission control systems, and to assume the total inspection function as Class A stations become increasingly more committed to maintenance and repair functions. In this program phase, a sufficient number of State-operated inspection stations would be implemented initially to inspect the 25 percent of the total vehicle population estimated to change ownership each year. This inspection would be conducted by means of the Key-Mode test, which would provide a dynamic exhaust emission test as compared with the static test of Phase I.

By confining the initial portion of the State-operated inspection capability to that portion of the vehicle population involved in title transfer actions, two benefits are derived. Because a large majority of ownership transfers are actually accomplished by the auto dealers, initial public contact by the fledgling organization and the associate scheduling problems will be minimized. In addition, this more comprehensive test regime will be operating on the average on an older segment of the vehicle population in which the benefits of the more rigorous inspection will be the greatest.

In addition to assuming prime responsibility for the mandatory Vehicle Emission Inspection Program, some State-operated stations will serve as training centers for inspection and maintenance personnel and will provide the base of operations for the State inspectors who monitor the inspection and repair activities of the Class A stations. When the inspection function is fully phased into the State stations, their functions will include audit of the maintenance conducted by the private stations, development of modified test procedures to meet new State and Federal emission standards, and provide test support of the program for the ultimate integrated vehicle test system.

The State-operated inspection stations can be designed to perform more than just the Key-Mode inspection test. Safety inspection also could be performed by these stations. Thus, vehicle change of ownership, being a significant milestone in a vehicle's service life, would be, in effect, a certification of the vehicle as a safe, emission controlled vehicle suitable for continued use. This inspection would determine also, under procedures correlatable with the 1972 Federal Test Procedure, whether emission control systems which are covered by a manufacturer's warranty are operating satisfactorily. The State thereby would be able to coordinate emission control system problems directly with the automobile manufacturers, using emission data obtained in its own facilities.

The recommended schedule for Phase II is shown in Figure 10-3. A brief description of the work involved in each of the principal Phase II tasks is presented below. The program would be initiated upon the passage of legislation by the California Legislature, and would be performed in sequence with Phase I.

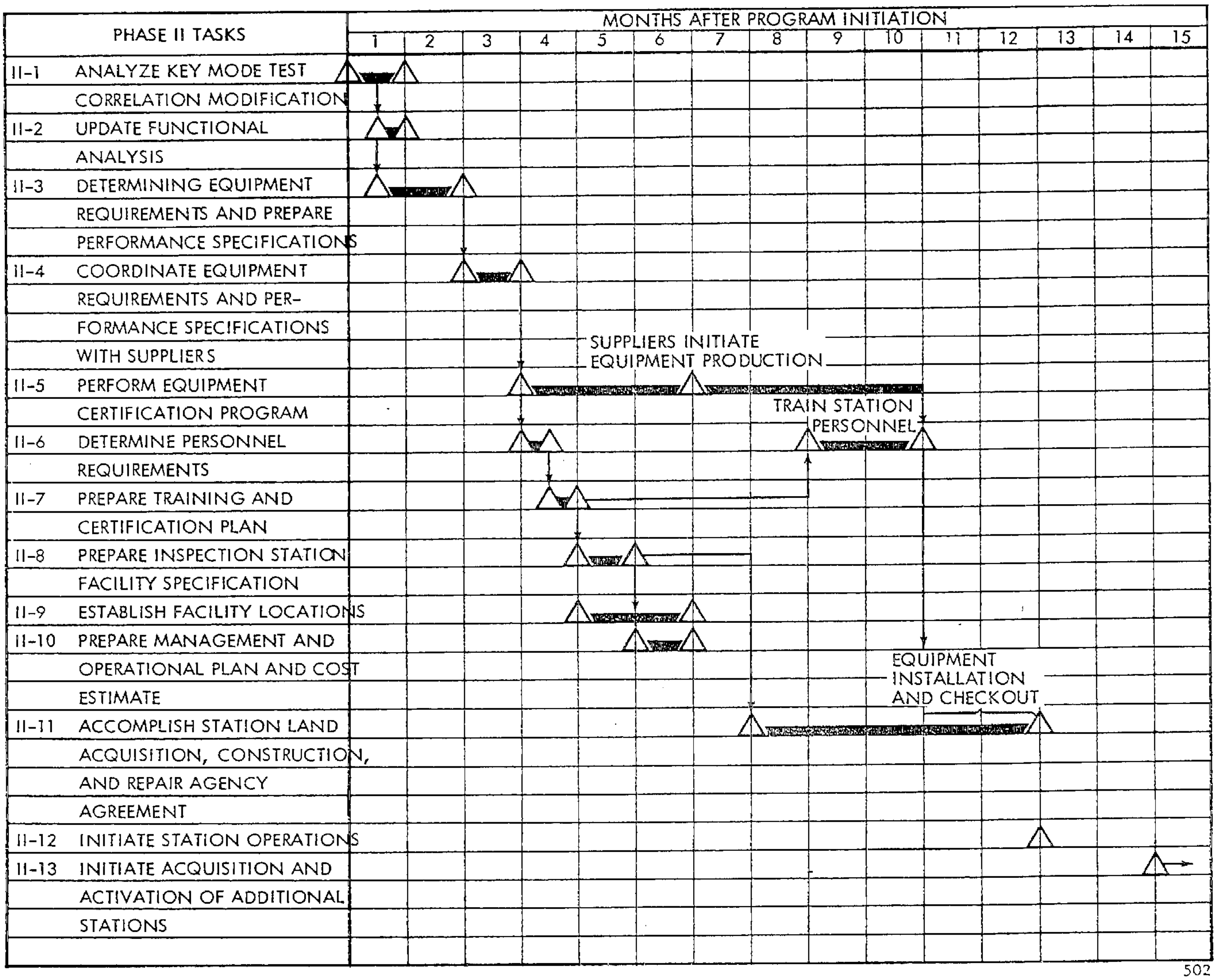


Figure 10-3. PHASE II - STATE-OPERATED SURVEILLANCE PROGRAM PLAN

10.2.2.1 <u>Task II-1: Key Mode Test Comparison with Federal Test Procedure</u> - Because of the benefits to be obtained by means of a test procedure that is correlatable with the 1972 Federal Test Procedure, the first task recommended for Phase II is an analytical comparison of the Key-Mode test with the 1972 Federal Test Procedure. The objective of the analysis would be to determine how to correlate the Key-Mode test with the Federal procedure. Some modification of the present Key-Mode test may be required to achieve correlation. This would be better to accomplish at the outset of the Phase II program rather than to wait until some future time, because of the controlling influence the test procedure has on the configuration of the total program. All elements shown in Figure 10-3 could conceivably be affected by a test procedure change, particularly equipment, personnel, facility, and training requirements, which are the high cost elements. Depending on the analysis and the scope and magnitude of test procedure changes found necessary, some testing might be required to verify the correlation of the two procedures.

10.2.2.2 Task II-2: Functional Analysis Update - The functional analysis performed on the Key-Mode test during the Part A feasibility analysis will be updated to reflect changes in the test procedure.

10.2.2.3 Task II-3: Equipment Requirements Analysis Performance and Specifications - Equipment and instrumentation requirements will be re-examined based on the revised functional analysis. The number of equipment sets will be determined from the Task II-8 analysis of facility locations. For each type of replaceable equipment item, a performance specification will be prepared, completely defining the functional and performance parameters of the item, including reliability, maintainability, and safety.

10.2.2.4 Task II-4: Coordination of Equipment Requirements and Specifications - The performance specifications will be coordinated with equipment suppliers known to supply the type of equipment specified. This coordination will include definition of the program objectives and of the intent to obtain equipment for certification. Equipment design proposals will be requested for review, and equipment selections for certification testing will be made on the basis of this review.

10.2.2.5 Task II-5: Test Equipment Certification Program - The test laboratory used in Phase I would be upgraded to the State-operated inspection station equipment configuration. The modified Key-Mode test will be used in the certification procedure. Certification will qualify the supplier to furnish his equipment to the State, contingent on the State's acceptance of his technical and cost proposal.

During the certification program, the personnel requirements, training plan, and facility requirements for the program will be validated. Following the equipment certification program, the test laboratory will be maintained for use in training State personnel for the manager, inspector, and technician job classifications associated with the Key-Mode test.

10.2.2.6 Task II-6: Personnel Requirements Analysis - Changes to the personnel requirements resulting from any modifications to the test procedure will be determined, as will the number of personnel required to staff the stations. The latter will be based on Task II-9 results.

10.2.2.7 Task II-7: Personnel Training and Certification - The training requirements developed during the Feasibility Study will be updated as required and a detailed plan will be developed, including a course outline tailored to the test procedure equipment and personnel. This plan will be implemented in the test laboratory upon completion of the equipment certification phase. Some of these personnel would be State personnel who performed as instructors or inspectors in the Phase I program.

10.2.2.8 Task II-8: Inspection Station Facility Specification - Based on the test procedure, personnel, equipment, and vehicle throughput requirements, a standard facility specification will be prepared. This document will specify the size of the station building, building areas, construction techniques and materials, equipment locations, driveways, parking areas, and landscaping. The document will be usable by the State to coordinate facility design requirements with the Architect-Engineer. The basic concept of the document will be to ensure that facility design configuration is based on the functions and operations to be performed at the facility.

10.2.2.9 Task II-9: Facility Locations Analysis - Vehicle population centers identified during the feasibility study would be analyzed to determine optimum locations of State-operated surveillance stations. Most of these stations would very likely be located in the 10 counties in which the Phase I program would be initiated. By means of this analysis, specific geographical locations by city will be established.

It then will be necessary to identify the availability of specific land that would be compatible for station size and operations. The California Highway Patrol Inspectors employed in the existing Certificate of Compliance program might be of assistance in these available land surveys in their respective geographic areas. The specific size of applicable lots and their cost will be determined. The facility specification developed in Tabk II-8 will be used in this survey.

10.2.2.10 Task II-10: Management and Operational Plan - This document will be a counterpart to the one prepared for the Class A Station Vehicle Emission Inspection and Maintenance Program. The State management structure recommended is common to both the privately-owned and the State-owned programs, as described in Section 9. The documents will be specialized, however, in the test procedure, equipment, personnel, and facility requirements, as well as station operations. The Phase II document will be used by station managers, technicians, and inspection personnel as the definitive requirements and policy guide for their respective functions.

10.2.2.11 Task II-11: Facility Construction - Facility construction would commence upon the State's purchase or leasing of the recommended lots. Facilities would be constructed to the Architect-Engineer's plans for standard California vehicle inspection stations. Construction work would be contracted by the State to local contractors. For compatibility with the phaseover of requirements for change of ownership testing to the State from Class A stations, it is recommended that all of the State stations constructed initially be built concurrently.

10.2.2.12 Task II-12: License Repair Garages and Initiate Operations - Based on the repair functions defined in the management and operational plan, the State would certify and license repair agencies to provide repairs required as a result of State-performed inspections of vehicles at change of ownership. All stations would initiate operations concurrently. Since these repairs will most certainly be accomplished in existing Class A stations, there should be no schedule problem in this regard.

10.2.2.13 Task II-13: Expand State Owned and Operated Test Facilities - After a 2-month shakedown period of operation of the pilot ownership transfer inspection program, the second element of Phase II should be initiated. This will consist of the activation of additional State-owned stations in sufficient quantity to provide inspection capability for essentially the entire vehicle population. This point in time represents a point at which an option could be exercised. If the audit of the Class A station inspection and maintenance program at this time indicates a high degree of effectiveness, a decision could be made to activate fewer additional

State-owned stations. It is recommended that the program plan allow consideration of this option at that time. Presently available information indicates that the cost effectiveness ratio of the Key-Mode inspection is so superior to others that no alternative can be firmly recommended for long-term implementation. However, since the effectiveness and cost of the recommended interim Class A program has not been evaluated, a direct comparison is not possible at the present time.

10.2.3 Phase III - Integrated Vehicle Test System

As vehicle emission control systems become more complex or more critical with respect to sensitivity of control required to meet the 90 percent emission reduction requirements of the 1970 Clean Air Act Amendments, it is foreseeable that the frequency of inspection and corrective maintenance will have to increase to meet emission standards. By 1975, automobiles should be equipped on a production line basis with integral inspection test systems, so that vehicle owners will automatically be informed of excessive emission levels in the course of vehicle operation.

This type of automatic test capability has been developed over the past 10 years for application to prime weapon systems and to many electromechanical systems used in industry. Such systems generally consist of sensors located at the key performance points of the equipment being monitored that are connected to either local or central information processing circuits and visual displays showing system performance. Such a system on an automobile could inform the operator of excessive emission level conditions by means of the light or gage type displays used on instrument panels today.

In addition, inspection test circuitry could be built into the production vehicle so that a standard connector interface could be provided for interface with inspection equipment. This connector would be in a readily accessible part of the vehicle and would be designed for optimum compatibility with the inspection test system and the human operator of that system. This type of test interface would accelerate vehicle inspection-test throughput rate, which is a significant factor in the cost of a periodic inspection program.

These are technological advances that can be currently forecast with assurance for the 1975 time-period. So that California can maintain its lead in air pollution control and bring the cost-effectiveness of advanced technology to bear on this control problem, it is recommended that a Phase III program be initiated by the first of 1973 in the application of integrated automatic inspection test capability to motor vehicles. The year 1975 is the one established by the Federal legislation for the introduction of 90-percent reduction controls on CO and HC, with NO_x to follow in 1976. The 2 years from 1973 to 1975 should allow adequate time to specify, design, develop, and produce integrated vehicle inspection test systems.

It is estimated that the analysis of system requirements could be completed over an 18-month period, during which interface sensor requirements would be analyzed and tested, along with control and display circuitry. These requirements would be documented in a performance specification which could then be coordinated with the Environmental Protection Agency and with the automobile manufacturers. Such a specification could provide the basis for vehicle automatic emission test system regulations to be promulgated by EPA under the Clean Air Amendments of 1970. It is estimated that within 18 months after promulgation of the requirements, automatic test systems could be designed and developed by vehicle manufacturers and incorporated into new motor vehicles.

SECTION 11
RECOMMENDED ADDITIONAL STUDIES

A number of additional study areas have been identified as a result of the wide range of vehicle testing, servicing, and program cost-effectiveness analysis performed as part of or in association with the feasibility study. The feasibility study provided an opportunity to examine in some detail the many elements of vehicle emission inspection and corrective maintenance technology. Many areas of this technology can be improved or advanced. The areas noted below are identified particularly because they are pertinent to the success of a periodic inspection and maintenance program. They were not included in the preceding implementation plan, because they represent detail elements of the larger tasks defined in that plan. The studies recommended for immediate consideration fall into four general categories:

a. Equipment Research
b. Statistical Analysis
c. Advanced Technology
d. Service Industry Problems.

11.1 EQUIPMENT RESEARCH

A study is required to verify the feasibility of ensuring that a qualified sample is supplied to the exhaust gas analyzers. Dilution of the exhaust sample must be detected and corrected. The measurement of oxygen content would be much less expensive than that of measuring CO_2 concentration and computing a carbon balance correction. The study would include a literature survey of the oxygen content of automobile exhaust, the design of an oxygen monitoring system (basically an assemblage of off-the-shelf hardware), and experimental evaluation of the acceptability of this method. It should be initiated at once so that the results can be made available in conjunction with the initiation of the related equipment definition tasks of the Implementation Plan.

11.2 STATISTICAL ANALYSIS

11.2.1 Extended Test Data Cost-Effectiveness Analysis

The study documented in this report has presented an analysis of the feasibility of mandatory vehicle emission inspection based upon the testing of 523 vehicles. Various statistical tests were made which show this sample to be statistically significant with associated confidence levels of 95 percent in error bands assigned. The total experiment is designed for 1,200 cars. Because of the inherently large variance of auto exhaust data, there is reason to expect, at test completion, some changes in the mean emission reduction and repair costs reported on the basis of the 523 cars tested to the date of this report.

Data obtained thus far substantiates Key-Mode testing as more cost-effective than the Idle test throughout the years of major emission reduction, but not significantly so. It is conceivable that the outcome may change when testing of 1,200 cars is completed.

Therefore, it is proposed that the cost-effectiveness analysis performed for Part A of this study be updated when the test results for the total 1,200 cars are available. The computer programs and plotting routines used in Part A would be exercised and the results presented. If the outcome does not change, the Part A recommendation will have been validated; should changes result, recommendations would be updated based upon the most complete evaluation obtainable.

11.2.2 Analysis of Additional Parameters

A variety of parametric data has been obtained to date that was not encompassed by the Part A analysis. These data cover parameters such as engine size, type of emission control device, number of cylinders, mileage, year, make, and model of vehicle. These data should be analyzed to identify any significant trends toward high emissions as a function of the various parameters not yet analyzed.

11.2.3 Analysis of Degradation Retest Data

Included in Part B of the overall study will be a tabulation and discussion of the results of a 6-month degradation retest on 600 previously tested cars. An important adjunct to this would be a statistical analysis of degradation with respect to those parameters identified in paragraph 11.2.2.

11.2.4 Failure Rate Analysis

Based upon the emission data from the Part B vehicle population sample of 1,200 cars, many highly significant results could be obtained if an analysis of the State's automobile exhaust emission distribution were performed in terms of correlating emission values with various vehicle parameters. For example, a cumulative percentage plot of population emittant levels as a function of emission level of HC, CO, and NO would indicate more precisely, than any data now available, the required emission level that would indicate a given emission percentile of vehicle population. Aside from the obvious application of providing emission "pass-fail" limits for the controlled and uncontrolled segments of the current automobile population, similar analyses could be conducted for any desired vehicle failure rate on the basis of engine size (CID), make, model year, type of pollution control device present on a class of vehicles, transmission type, or any combination of two or more of these or other variables recorded.

In addition, total emission reductions achievable could be determined as a function of emission limits prescribed. In general, one would not expect a linear relationship to exist between vehicle failure rate and total emission reduction achievable, simply because lower per-vehicle emission reductions result from servicing "cleaner" cars.

This form of analysis, coupled with vehicle owner service costs, would allow one to predict not only average service cost as a function of vehicle failure rate (and the corresponding emission limits), but the most service-cost-effective emission limits could be predicted as well. That is, those emission limits resulting in the greatest emission reduction per service-dollar spent could be determined.

11.3 ADVANCED TECHNOLOGY

A number of research and development efforts are presently underway that could possibly advance the technology for the maintenance of motor vehicles and their exhaust emission levels. A survey is recommended to identify these technological efforts and to determine their effect on a vehicle inspection and maintenance program. The study would determine the availability of, and the requirements for, technology affecting vehicle exhaust emissions. Items in the study would include, but not be limited to:

- Emission control systems and automatic test
- Instrumentation for measurement
- External or integrated vehicle sensing for engine diagnosis
- Induction systems, including electronically controlled fuel injection, that are relatively maintenance-free
- Maintenance-free ignition distributors
- Spark plug and ignition wiring life and replacement policies.

11.4 SERVICE INDUSTRY PROBLEMS

The feasibility study has identified significant areas related to the service industry that could reduce the effectiveness of a mandatory inspection system. These areas include service quality, equipment practices, and replacement parts control. The problems in these areas could be solved to a large extent by training and motivational efforts.

11.4.1 Training Requirements

The repair service industry lacks sufficient knowledge in the basic fundamentals of current emission control systems. The automobile technician has limited knowledge regarding the diagnosis and repair of these systems. This problem could be solved by implementing accredited emission control training courses through the California State Department of Education. As determined through the feasibility study (Volume III, paragraph 4.7), the approved course would require 142 hours for the Key-Mode test regime. The automobile technician would be required to complete the course successfully prior to taking the Class A examination test. Such training would provide technicians with a solid technical foundation in the operation of the various tuneup and emission control systems. Currently, the experienced automobile technician has a limited amount of practical knowledge on servicing and repairing these systems in accordance with manufacturer's specifications. As a result, the technician may become frustrated on a particular smog device problem and give up, leaving the car unrepaired and with high emissions. Although service manuals do an excellent job of describing the tuneup and emission control systems and how to service them, most leave much to be desired on the fundamentals of operation. Fundamentals are extremely important if the automobile technician wants to keep up with the advancing technology.

A study is recommended to define the optimum training program approach. In the training program, comprehensive emission control and tuneup systems training would be provided. Many vocational schools with automobile shops are available throughout California and could incorporate this type of training as an additional supplement to their curriculum. Currently, San Bernardino Valley College is one of the very few schools which offers this comprehensive training as an accredited course. It is now being considered as a requirement in the vocational automobile shop program for graduation from the college.

Comprehensive training programs for automobile technicians could be implemented similar to the methods outlined in Volume III, Section 4. Qualification for instructors to teach this course should be as rigid as those outlined for inspection instructors. The total program could be implemented through the California Department of Education. Lesson plans (already available), related text books, and special instructor seminars could be offered as a package to train the instructors. The most effective incentive to get technicians into a training program would be to require comprehensive training through the public schools as a prerequisite for obtaining a Class A license.

11.4.2 Replacement Parts Control

If the automobile service industry is required to perform low emission tuneups to pass inspection, then the parts industry must supply the automobile technician with quality replacement parts. Parts which are improperly serviced and adjusted during the assembly (or rebuilding) process could cause excessive emissions as well as poor driveability. A survey of problems in this area may be justified to determine the scope and magnitude of parts control deficiencies. Quality control of tuneup replacement parts must be studied prior to the implementation of mandatory inspection. There are some examples of replacement parts that are grossly defective or maladjusted which in turn can cause high emissions and poor driveability. Two examples are presented below to show the possible problems that will undoubtedly prevail as the inspection program is implemented:

a. It is well known that some new and rebuilt distributors are being supplied to the industry with a built-in point opening variation greater than 5 degrees, and some are as high as 7 or 8 degrees variation. The variation in the point open signal also varies the ignition timing from cylinder to cylinder. This can cause rough idle and higher HC emissions even though all other adjustments are correct.

b. Another problem occurred when a test vehicle was accepted for test in the Part B pilot program. The vehicle received a major tuneup but the wrong flange gasket was supplied with the carburetor gasket kit. As a result, the power valve was operating at all engine load conditions, because the power valve vacuum passage was blocked by the gasket. The problem was remedied by drilling a hole through the gasket.

Admittedly, the repair technician should have watched for this type of problem. However, the flange gasket in this kit was probably manufactured to fit many carburetor applications. This points out the need for maintaining rigid quality control with respect to product application.

It is recognized that the incidence of low quality parts may not exist, but it should be studied to determine the impact on emission inspection and repair effectiveness.

11.4.3 Mechanic Motivation

One factor that has been clearly identified in this study has been a general lack of motivation on the part of the mechanics that performed service on the failed test vehicles. Several of the service garages used were very enthusiastic in support of exhaust emission reduction and recognized the business potential of encouraged, if not required, tuneups on a yearly basis; however, these organizations were in the minority. The majority of garages performed their normal day-to-day operations without demonstrating a real interest in the program. Quality control was generally lacking. Out-and-out fraudulent practices were not detected but a number of services were of suspect quality. This is believed due to lack of quality control rather than mechanic dishonesty.

Because the success of a vehicle exhaust emission inspection and maintenance program depends on highly motivated mechanics, a study is recommended to identify factors which influence this motivation. The study would include:

- Survey of background, education, skill levels, capabilities
- Study of instrumentation, tools, and procedures for diagnosis
- Recommendations for upgrading skills, improving procedures, visual aids
- Recommendations for improvements in diagnostic instruments and tools
- Recommendations for a quality control program to ensure satisfactory repair.